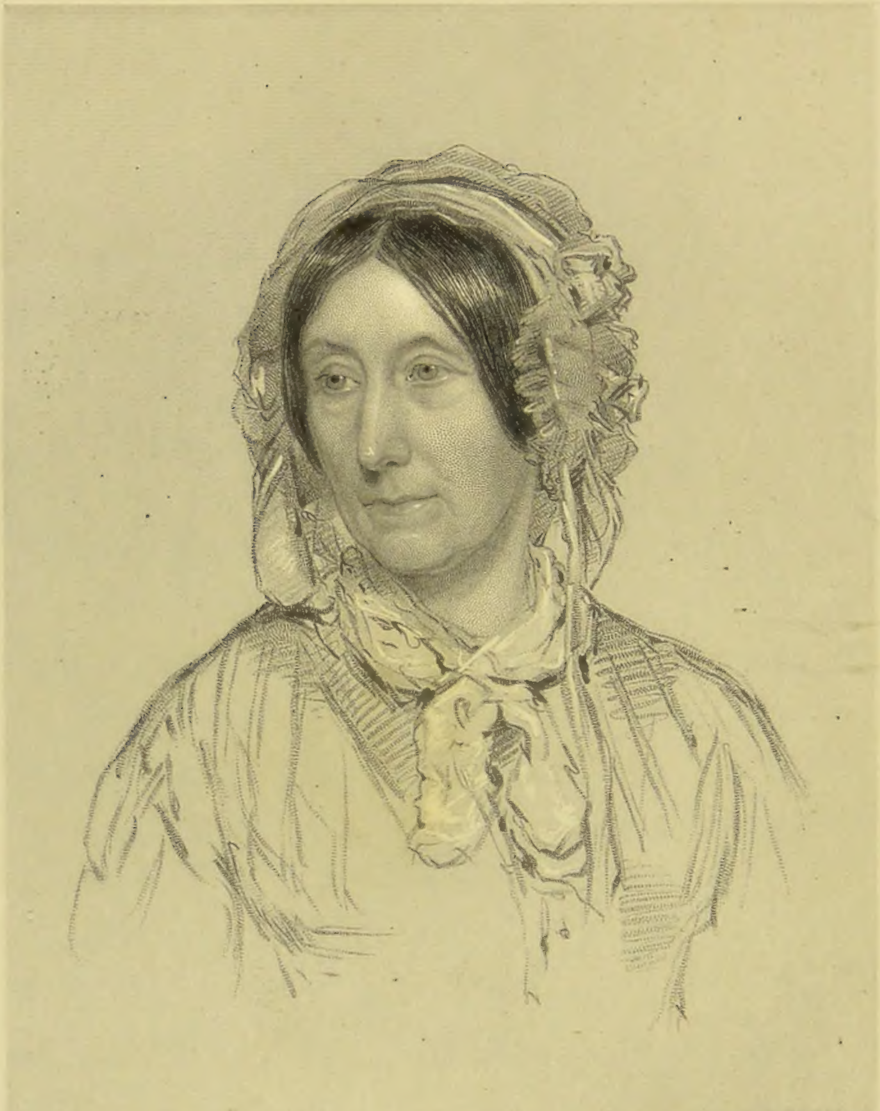
PHYSICAL GEOGRAPHY



W. Holl, sc.

Mary Somerville.

From a drawing by James R. Swinton Esq.

London, John Murray, Albemarle Street.

PHYSICAL GEOGRAPHY

By MARY SOMERVILLE

AUTHOR OF 'MECHANISM OF THE HEAVENS' ETC.

SEVENTH EDITION, REVISED

WITH PORTRAIT

LONDON
JOHN MURRAY, ALBEMARLE STREET
1877

LONDON : PRINTED BY
SPOTTISWOODE AND CO., NEW-STREET SQUARE
AND PARLIAMENT STREET

TO

SIR JOHN F. W. HERSCHEL, BART., K.H.

&c. &c. &c.

DEAR SIR JOHN,

I have much pleasure in again availing myself of your permission to inscribe this book to you, as it gives me an opportunity of assuring you once more of my admiration of your talents, my high appreciation of the services you have conferred upon science, and of my sincere estimation of your friendship.

I remain, with great regard,

Yours truly,

MARY SOMERVILLE.

La Spezzia.

PREFACE

TO

THE SEVENTH EDITION.

GREAT CARE has been taken in this edition to incorporate, as far as could be done without interfering with the plan of the work and the general views of the author, the most important of recent geographical discoveries and conclusions, and to eliminate such matter as had been rendered obsolete by the lapse of time, or proved, by more exact observation and scientific research, to be inaccurate or untrustworthy.

For these purposes the Editor has consulted, among other works too numerous to be conveniently specified here, the 'Journals,' and 'Transactions' of the Royal Geographical Society; 'The Geographical Magazine;' the 'Geographisches Jahrbuch,' by E. Behm; 'Die Bevölkerung der Erde,' by E. Behm and H. Wagner; the 'Almanach de Gotha;' 'Reports of Official Surveys and Explorations;' and books of recent travels and geographical investigations.

This edition contains some features which will be at once recognised as new by all readers of former editions; *e.g.*, the heads of subdivisions of chapters have been

marked by distinctive type; etymologies, definitions, and explanations of numerous scientific terms have been added in foot notes; the 'Table of Heights above the Sea,' which formed the appendix to previous editions, has been rendered unnecessary by the addition of all the chief heights to the text; and last, but not least, the Index has been thoroughly revised and greatly enlarged.

LONDON: *February* 1877.

CONTENTS.

CHAPTER I.

GEOLOGY.

CHAPTER II.

GENERAL VIEW OF THE CONTINENTS.

CHAPTER III.

HIGH LANDS OF THE GREAT CONTINENT.

CHAPTER IV.

HIGH LANDS OF THE GREAT CONTINENT—*continued.*

CHAPTER V.

HIGH LANDS OF THE GREAT CONTINENT—*continued.*

CHAPTER VI.

SECONDARY MOUNTAIN SYSTEMS OF THE GREAT CONTINENT.

CHAPTER VII.

THE SOUTHERN LOW LANDS OF THE GREAT CONTINENT.

CHAPTER VIII.

AFRICA.

CHAPTER IX.

THE CONTINENT OF AMERICA.

CHAPTER X.

SOUTH AMERICA.

CHAPTER XI.

CENTRAL AMERICA.

CHAPTER XII.

NORTH AMERICA.

CHAPTER XIII.

NORTH AMERICA—*continued.*

CHAPTER XIV.

ISLANDS OF THE PACIFIC AND INDIAN OCEANS.

CHAPTER XV.

CORAL FORMATIONS, VOLCANIC ACTION, AND EARTHQUAKES.

CHAPTER XVI.

THE ARCTIC AND ANTARCTIC REGIONS.

CHAPTER XVII.

MINERALS.

CHAPTER XVIII.

THE OCEAN.

CHAPTER XIX.

RIVERS.

CHAPTER XX.

ASIATIC RIVERS.

CHAPTER XXI.

AMERICAN AND AUSTRALIAN RIVERS.

CHAPTER XXII.

LAKES.

CHAPTER XXIII.

ATMOSPHERIC PHENOMENA.

CHAPTER XXIV.

ATMOSPHERIC PHENOMENA—*continued.*

CHAPTER XXV.

VEGETATION.

CHAPTER XXVI.

VEGETATION—*continued.*

CHAPTER XXVII.

VEGETATION—*continued.*

CHAPTER XXVIII.

VEGETATION—*continued.*

CHAPTER XXIX.

VEGETATION—*continued.*

CHAPTER XXX.

DISTRIBUTION OF INSECTS.

CHAPTER XXXI.

DISTRIBUTION OF FISHES, MOLLUSCA, INFUSORIA, AND MARINE MAMMALIA.

CHAPTER XXXII.

DISTRIBUTION OF REPTILES.

CHAPTER XXXIII.

THE AMPHIBIA.

CHAPTER XXXIV.

DISTRIBUTION OF BIRDS.

CHAPTER XXXV.

DISTRIBUTION OF MAMMALIA.

CHAPTER XXXVI.

DISTRIBUTION, CONDITION, AND PROSPECTS OF THE HUMAN RACE.

PHYSICAL GEOGRAPHY.

CHAPTER I.

GEOLOGY.

§ 1. **Of Physical Geography.**[1]—*Physical Geography* is a description of the earth, the sea, and the air, with their inhabitants animal and vegetable, so far as regards the distribution of these organised beings, and the causes of that distribution. Political and arbitrary divisions are disregarded, the sea and the land are considered only with respect to those great features that have been stamped upon them by the hand of the Almighty, and man himself is viewed but as a fellow-inhabitant of the globe with other created things, yet influencing them to a certain extent by his actions, and influenced in return. The effects of his intellectual superiority on the inferior animals, and even on his own condition, by the subjection of some of the most powerful agents in nature to his will, together with the other causes which have influenced his physical and moral state, are among the most important subjects of this science. The previous states of our terrestrial habitation, the successive changes which have gradually led to its present geographical arrangement, and to the existing distribution of land and water, so powerfully influential on the destinies of mankind, are circumstances of primary importance.

§ 2. **Position of the Earth in the Solar System.**—*The position of the earth* with regard to the sun, and its connexion with

[1] In Mr. Cooley's work, *Physical Geography* is described as 'the department of science which embraces the course of physics reigning on the earth's surface, over land, sea and air, and of which, as it depends to some extent on the feature of that surface, geography is a function.'—Physical Geography,' preface, p. v.

the bodies of the solar system,[1] have been noticed in another work of the author's.[2] It has been there shown that our globe forms but an atom in the immensity of space, utterly invisible from the nearest fixed star,[3] and scarcely a telescopic object to the remoter planets[4] of our system. The increase of temperature,[5] with the depth below the surface of the earth, and the tremendous desolation hurled over wide regions by numerous fire-breathing mountains, show that man is removed but a few miles from immense lakes or seas of liquid fire.[6] The very shell on which he stands is unstable under his feet, not only from those temporary convulsions that seem to shake the globe to its centre, but from a slow, almost imperceptible, elevation in some places, and an equally gentle subsidence in others, as if the internal molten matter were subject to secular tides, now heaving and now ebbing, or that the subjacent rocks were in one place expanded and in another contracted by changes of temperature.

The earthquake and the torrent have torn the solid earth and opened the seals of the most ancient records of creation, written in indelible characters on the 'perpetual hills and the everlasting mountains.' There we read of the changes that have brought the rude mass to its present fair state, and of the myriads of organic species that have appeared on this mortal stage, have fulfilled their destinies, and have successively disappeared to make way for new races, which, in their turn, have vanished from the scene, till the creation of man completed the glorious work. Who shall define the periods of those mornings and evenings when God saw that His work was good? and who shall declare the time allotted for the human race, when the generations of the most insignificant

---

1 The *Solar System* (from Lat. *sol*='the sun') is that assemblage of celestial bodies which consists of the *sun and his attendant planets*, including *comets* and *meteoric bodies.*

The order of *distance* from the sun of the eight great planets of this system is as follows:—1. Mercury. 2. Venus. 3. Earth. 4. Mars. 5. Jupiter. 6. Saturn. 7. Uranus. 8. Neptune.

2 Somerville's 'Connexion of the Physical Sciences.'

3 The nearest fixed star is said to be more than 19,000,000,000,000 miles distant from the earth.

4 *Uranus* (1,752,851,000 miles) and *Neptune* (2,750,000,000 miles) are the most remote planets.

5 This increase is estimated to be at the rate of 1° Fahrenheit for every 54 feet, or thereabouts, from the earth's surface. But as observation on this point has nowhere been extended to the depth of one mile from the surface, all that can be safely expressed about it is that throughout such depths as have been penetrated the temperature increases with the descent.

6 This doctrine of a thin crust and a molten interior is now meeting with considerable opposition. (See Green's 'Geology for Students,' cap. xi.)

insect existed for unnumbered ages? Yet man also is to vanish in the ever-changing course of events. These stupendous changes may be but cycles in those great laws of the universe where all is variable but the laws themselves, and Him who ordained them.

§ 3. **The Earth's distance from the Sun: and the Civil Year.**—The earth is one of 169 planets which revolve about the sun in elliptical orbits: of these 161 have been discovered since the year 1781. Mercury and Venus are nearer the sun than the earth, the others are more remote: 161 are of small dimensions, revolve between the orbits of Mars and Jupiter, and are called *Asteroids.* The earth revolves at a mean distance of 91,600,000 m. from the sun's centre, in a civil year of 365 days 6 hours 9 minutes and 9·6 seconds, at the same time that it rotates in 23 hours 56 minutes and 4 seconds, about an axis which always remains parallel to itself, and inclined at an angle of 23° 27′ 28″·75 to the plane of the ecliptic;[1] consequently the days and nights are of equal length at the equator, from whence they progressively differ as the latitude increases, till at each pole alternately there is perpetual day for six months, and a night of the same duration: thus the light and heat are very unequally distributed, and both are modified by the atmosphere which surrounds the earth.

With regard to *magnitude*, Mars, Jupiter, Saturn, Uranus, and Neptune, are larger than the earth; Mercury and Venus are smaller: but even the largest is incomparably inferior to the sun in size: his mass is 354,936 times greater than that of the earth, but the earth is nearly four times as dense.

§ 4. **The Moon's distance: Earth's figure and density as indicated by the Moon's motion.**—Though the Planets disturb the earth in its motion, their *form* has no effect on account of their great distance; but it is otherwise with regard to the *Moon*, which revolves about the earth at a mean distance of 238,793 m., and is therefore so near that the form of both bodies causes mutual disturbances in their respective motions. The perturbations in the moon's motions from that cause, compared

---

[1] The *Ecliptic* (from ἐκλειπτικός = 'belonging to an eclipse') is a great circle of the sphere which the sun appears to describe in a year, but which is really described by the earth in that time.

Obs. 1. The ecliptic is so called from the fact that *eclipses* of the sun or moon can only occur when the latter is on or very near this circle.

Obs. 2. When the ecliptic is spoken of in connexion with geography, it is a great circle on an artificial globe which cuts the equator at an angle of 23° 28′ in two diametrically opposite points that is meant. It represents the successive parallels at which the sun is vertical during the earth's annual revolution.

with the same computed from theory, show that the earth is not a perfect sphere, but that it bulges at the equator, and is flattened at the poles: they even give a value of this compression [1] or flattening. Again, theory shows that, if the earth were throughout of the same density, it would be much less compressed at the poles than the moon's motions show it to be, but that it would be very nearly the same were the earth to increase regularly in density from the surface to its centre; and thus the lunar motions not only make known the form, but reveal some important facts as to the internal structure of our globe. *Actual measurement* has proved the truth of these results. The courses of the great rivers, which are generally navigable to a considerable extent, show that the curvature of the land differs but little from that of the ocean; and, as the heights of the mountains and continents are inconsiderable when compared with the magnitude of the earth, its figure is understood to be determined by a surface at every point perpendicular to the direction of gravitation, and is the same which the sea would have if it were continued all round the earth beneath the continents. Such is the figure that has been measured in various parts of the globe.

§ 5. **Figure of the Earth from the measure of Arcs of the Meridian.**—*A terrestrial meridian* is a line passing through both poles all the points on which have their noon contemporaneously. The lines perpendicular to it are the *parallels* [2] *of latitude.* Now, if the earth were a perfect sphere, all degrees of latitude would be of the same length; but, as it is flattened at the poles, the degrees are longest there, and decrease in length to the equator. The *form* and *size* of the earth may therefore be determined by comparing the lengths of degrees of the meridian in different latitudes.[3] Twelve arcs have been measured in Europe,[4] one in North America, one in the Andes of equatorial America, two

---

1 The compression of the earth is the flattening at the poles. Its numerical value is equal to the difference between the equatorial and polar diameters, expressed in feet or miles.

The *Equatorial Diameter* is 7925·6 miles.
" *Polar Diameter* " 7899·2 "
" *Polar Compression* " 26·4 " or $\frac{1}{299}$ of the *Mean Diameter.*

2 The *Parallels* (from παρά = 'beside,' and ἀλλήλων = 'of one another') are small circles drawn parallel to the equator.

3 The theoretical investigation of the figure of the earth, the method employed for measuring arcs of the meridian, and that of deducing the form of the earth from the oscillations of the pendulum, are given in the 6th section of the 'Connexion of the Physical Sciences,' by Mary Somerville, 8th edition.

4 Viz.:—Two in England, two in France, one in Hanover, one in Prussia, one in Denmark, two in Russia, two in Sweden, and one at Rome.

in British India, and two at the Cape of Good Hope; but a comparison of no two gives identical results, which shows that the earth has a slightly *irregular form*. From a mean of 10 of these arcs M. Bessel deduced that the *equatorial radius* of the earth is 3963·025 m. and the *polar radius* 3949·8 m. Whence, assuming the earth to be a sphere, the length of a *mean degree* of the meridian is 69·05 British statute m., therefore 360 degrees, or the whole circumference of the globe, is 24,858 m.; the *diameter*, which is something less than a third of the circumference, is about 8286 statute m.; and the length of a geographical mile of 60 to a degree is 6086·76 ft. The breadth of the torrid zone is 3242 m., the breadth of each of the temperate zones is 3290 m., and that of each of the spaces within the arctic and antarctic circles 1313 m. nearly. The results obtained by Mr. Airy, the Astronomer Royal, 10 years afterwards, only differ from those of M. Bessel by 117 ft. in the equatorial, and 148 ft. in the polar radius. In consequence of the round form of the earth, the dip or depression of the horizon is in round numbers 6 ft. for every 3 m. of distance; that is to say, an object 6 ft. high would be hid by the curvature of the earth at the distance of 3 m. Since the dip increases as the square, a hill 600 ft. high would be hid at the distance of 10 m., and the top of Mount Everest[1] (29,002 ft.), the most elevated point of the Himalaya hitherto measured, would be seen to sink beneath the horizon by a person about 169 m. off: thus, when the height is known, an estimate can be formed of the distance of a mountain by observing its angular distance above the sea-horizon.

§ 6. **Figure of the Earth as indicated by Oscillations of the Pendulum.**—The oscillations of the pendulum have afforded another method of ascertaining the form of the earth. Like all heavy bodies, the descent and oscillations of the pendulum are accelerated in proportion to the force of gravitation, which increases from the equator to the poles. In order, therefore, that the oscillations may be everywhere performed in the same time, the length of the pendulum must be increased progressively in going from the equator to the poles, according to a known law[2]

---

[1] So called after Colonel Everest by Colonel Waugh, who first determined its altitude. The *Hindus* call it *Gaurisankar*; the *Tibetans* and *Nepalese*, *Chingopamari*.

[2] A pendulum which oscillates 86,400 times in a mean day at the equator, will do the same at every point of the earth's surface if its length be increased progressively to the pole as the square of the sine of the latitude. The sine of the latitude is a perpendicular line drawn from any point of a terrestrial meridian to the equatorial radius of the earth. That line expressed in feet or miles, and multiplied by itself, is the square of the sine

from whence the compression or flattening at the poles may be deduced. Experiments for that purpose have been made in many places; but, as in the measurement of the meridian arcs, no two sets give exactly the same results. The *mean* of the whole, however, differs very little from that given by the measurement of degrees of the meridian and the perturbations of the moon; and, as the three methods are so entirely independent of each other, the *figure* and *dimensions* of the earth may be considered to be known with great accuracy. The sea has little effect on these experiments, both because its density is less than that of the earth, and that its mean depth of nearly 4 m. is inconsiderable when compared with 3956 m. the mean terrestrial radius.[1]

The discrepancies in the results from the comparison of the different sets of pendulum experiments, and also of measured degrees of the meridian, can only arise from *local attraction*, and from *irregularities* in the form of the earth's surface. These attractions, produced by dense masses of rock or mountains, cause the plumb line to deviate from the vertical, and when under ground they alter the oscillations of the pendulum. General Sabine, who made experiments with the pendulum from the equator to within 10 degrees of the N. pole, discovered that the intensity is augmented by volcanic islands. A variation to the amount of one-tenth of a second in 24 hours can be perfectly ascertained in the rate of the pendulum; but from some of these local attractions a variation of nearly 10 seconds has occurred during the same period. The islands of St. Helena, Ascension, St. Thomas, and Mauritius, are some of those noted by General Sabine.

There are other remarkable instances of local disturbance, arising from the geological nature of the soil; for example, the intensity of gravitation is smaller at Bordeaux, from whence it increases rapidly to Clermont-Ferrand, Milan and Padua, where it attains a maximum (owing probably to dense masses of rock under ground), and from thence it extends to Parma. In consequence of this local attraction, the degrees of the meridian in that part of Italy seem to increase in length towards the equator through a small space, instead of decreasing, as if the earth were drawn out instead of flattened at the poles.

It appears from this, that the effect of the whole mass of the globe on a pendulum or torsion balance[2] may be compared with the

---

of the latitude. Gravitation increases from the equator to the poles according to that law, and the length of the degrees augments very nearly in the same ratio.

[1] The inequalities in the motions of the moon and earth are explained in Sections 5 and 11 of the 'Connexion of the Physical Sciences.'

[2] The *Torsion* (Lat. *tortio*, from *torqueo*='I twist') *Balance* is a

effect of a small part of it, and thus a comparison may be instituted between the mass of the earth and the mass of that part of it. Now a leaden ball was weighed against the earth by comparing the effects of each upon a balance of torsion; the nearness of the smaller mass making it produce a sensible effect as compared with that of the larger, for by the laws of attraction the whole earth must be considered as collected in its centre. In this manner a value of the *mass* of the earth was obtained; and, as its *volume* was known, its *mean density* was found to be 5·6 times greater than that of water at the temperature of 62° Fahr. Now, as that mean density is double that of basalt, and more than double that of granite rocks which undoubtedly have emanated from very great depths beneath the surface, it affords another proof of the increase in density towards the earth's centre. These experiments were first made by Cavendish and Michell, and afterwards with additional precautions by Baily, who devoted four years of unremitted attention to the accomplishment of this important and difficult research.[1]

§ 7. **Outline of Geology.**—Although the earth increases in density from the surface—where its *mean specific density* is 5·6—to the centre, where it is probably about 11, as might naturally be expected from the increasing pressure, yet the surface consists of a great variety of substances of different densities, some of which occur in *amorphous* [2] masses; while others are disposed in regular

---

machine which was invented by M. Coulomb for measuring the intensities of electric, or magnetic forces, by establishing an equilibrium between them and the force of torsion. Cavendish made an interesting application of the torsion balance when he used it to measure the force of attraction of two leaden spheres in his famous experiment to determine the mean density of the earth.

[1] Mr. Airy made a series of experiments to ascertain the mean density of the earth by comparing the simultaneous oscillations of two pendulums, one at the bottom of the Harton Coal Mine in Northumberland, 1,260 ft. deep, and the other on the surface of the earth perpendicularly above it. The oscillations were compared with an astronomical clock at each station, and the time was instantaneously transmitted from one to the other by a telegraphic wire. The oscillations were observed for more than 100 hours consecutively, when it was found that the lower pendulum made two oscillations more in 24 hours than the upper one. The places of the pendulums were then reversed and the experiment repeated for the same length of time with the same result. The difference in the number of oscillations at the two stations showed that gravitation at the bottom of the mine exceeded that at the surface by the $\frac{1}{19190}$ part, and that the mean density of the earth deduced therefrom was 6·565.

[2] Rocks which are not crystallised in definite form are called *Amorphous Rocks.*

layers or strata, either horizontal or inclined at all angles to the horizon. By mining, man has penetrated only a very little way; but by reasoning from the dip,[1] and from other circumstances, he has obtained a fairly accurate idea of the structure of our globe to the depth of about 10 m. All the substances of which we have any information are divided into *four classes*, distinguished by the manner in which they have been formed: namely *Plutonic*, and *Volcanic, rocks*, both of igneous origin, though produced under different circumstances; *Aqueous or Stratified rocks*, entirely due to the action of water, as the name implies; and *Metamorphic rocks*,[2] originally deposited by water, and consequently stratified, but subsequently altered from their original state and crystallised. The aqueous and volcanic rocks are formed at or near the surface of the earth, the plutonic and metamorphic at greater depths; but all of them have originated simultaneously during every geological period. The antagonistic principles of fire and water have ever been and still are the cause of the perpetual vicissitudes to which the crust of the earth is liable.

Opinion with regard to the formation of the igneous crystalline rocks by the cooling of fused matter under immense pressure has been greatly modified, chiefly by the experiments of the continental chemists, who have come to the conclusion that water combined with intense heat and pressure must have had an important share in these operations from the most remote geological periods. It has long been known that substances combine chemically with certain portions of water while crystallising, and that the same substance crystallising at different temperatures combines with different quantities of water, and assumes a corresponding variety of forms. Now granite and such of the metamorphic rocks as owe their structure to heat and great pressure are highly crystalline, and by numerous synthetic experiments it has been clearly proved that water has been as necessary to their formation as heat and pressure. The earthquake, the elevation and disruption of the terrestrial strata, and the torrents of lava that flow from numerous volcanoes, are sufficient proofs that abundance of water in the state of steam at a high pressure exists in the interior of the earth.

It has been inferred that the *plutonic* rocks (Granite, Syenite, &c.) were formed at great depths in the earth, and have cooled and slowly crystallised under intense pressure, and where the con-

[1] The inclination of beds downwards into the earth is called their *dip*.

[2] *Metamorphic* (Gr. μετά = 'change'; and μορφή = 'form') *Strata* = altered strata.

tained gases could not expand, were then heaved up in unstratified masses, by the elastic force of the internal heat, even to the tops of the highest mountains, or forced in a semi-fluid state into fissures of the superincumbent strata, sometimes into the cracks of the previously formed granite;[1] for that rock, which constitutes the base of so large a portion of the earth's crust, has not been all formed at once; some portions had been solid, while others were yet in a liquid state. This class of rocks is completely destitute of fossil[2] organic remains.

Although granite and *volcanic* rocks are both due to the action of fire, their nature and position are very different; granite, fused in the interior of the earth, has been probably cooled to a certain extent before coming to the surface: besides, it consists of few ingredients (chiefly felspar, quartz, and mica), so that it has nearly the same mineralogical character in all countries. But as the volcanic fire rises to the very surface of the earth, fusing whatever it meets with, volcanic rocks assume various forms, not only from the varied kinds of strata which are melted, but from the different conditions under which the liquid matter has been cooled, and the different proportions of water with which it combines—circumstances that seem to have had the greatest effect on its appearance and structure. Sometimes it assumes a crystalline granitic structure, at others it becomes vitreous, or like glass; in short all those massive, unstratified, and occasionally columnar rocks, as basalt, greenstone, certain porphyries, and perhaps serpentine, are due to volcanic action, and are consequently devoid of organic remains.

There seems scarcely to have been any age of the world in which volcanic eruptions have not taken place in some part of the globe. Lava has pierced through every description of rocks, spread over the surface of those existing at the time, filled their crevices, and flowed between their strata. Ever changing its place of action, it has burst out at the bottom of the sea as well as on dry land. Enormous quantities of scoriæ and ashes have been ejected from numberless craters,[3] and have formed extensive deposits in the sea, in lakes, and on the dry land, in which

[1] Elevations of the earth's surface, and the displacement of rocks, are ascribed by others to the *earth's contraction*. (See Green's 'Geology for Students,' cap. xi.)

[2] *Fossil* (Lat. *fossilis*, from *fodio* = 'I dig') is, literally, anything *dug* out of the earth. It is a term which is now almost exclusively applied to organic remains.

[3] *Crater*, the cup-shaped orifice of volcanoes; craters may be *central* or *lateral* in the mountain in which they occur.

are embedded the remains of the animals and vegetables of the epoch.

There can be no doubt that *metamorphic rocks,* such as gneiss, mica-schist, clay-slate, quartz rock, statuary marble, dolomites,[1] &c., were formed of the sediment of water in regular layers, differing in kind and colour, and that they have acquired a crystalline structure, but that the change has been invariably effected in consequence of their proximity to deep-seated fused matter. The term *metamorphic* is applied now to any sedimentary rock that is altered from its original state to a hard or crystalline structure, without reference to any theory by the agency of which the change was produced, however diversified the nature of the rock may be. In fact Chemical Geology, a modern branch of science, has proved that the term metamorphic, taken in its widest sense, might be applied to every *altered* rock, be its age or nature what it may. It is possible that highly crystallised strata which extend over thousands of square miles may have occasionally acquired their crystalline character from transmitted heat combined with steam and chemical action under enormous pressure.[2] Mr. Darwin estimated, from the number of volcanoes in simultaneous eruption in the Chilian Andes in the year 1835, that a subterraneous lake of liquid lava twice as large as the Black Sea was in all probability formed under the southern extremity of the American continent,[3] and the internal fire was certainly not less energetic in the early geological eras. An earthy stratum has sometimes been changed into a highly crystallised rock, to a considerable distance from the point of contact, by heat thus transmitted; and there are instances of dark-coloured limestone, full of fossil shells, that has been changed into statuary marble from the same cause. Such alterations may frequently be seen to a small extent on rocks adjacent to a stream of lava.

Notwithstanding these instances, it would be a great error to suppose that metamorphism is always connected with internal heat, even in formations of great extent; for it frequently happens that crystalline strata alternate with others of vast thickness

---

1 *Dolomite* is the name applied to a calcite consisting of an equal number of molecules of carbonates of limestone and magnesia. It takes its name from *Dolomieu*, the French geologist and mineralogist.

2 The whole question of metamorphism in rocks has been admirably treated in a prize essay presented to the Institute of France by M. Daubrée (*Etudes sur le Métamorphisme des Roches Crystallines*, Paris, 1859), in which its author has rendered every justice to the first propagator of the theory, our countryman James Hutton.

3 See 'Naturalist's Voyage round the World,' p. 311.

through which the heat could not have been transmitted. The physical forces are really metamorphic, and have an important share in those changes which the formations of all ages seem to undergo; the whole phenomena of metamorphism are extremely complicated, but synthetic chemistry is daily throwing light upon this difficult subject.[1]

There is seldom a trace of organic remains in the crystalline stratified rocks; their strata are sometimes horizontal, but they are usually tilted at all angles to the horizon, and form some of the highest mountains and most extensive table-lands on the face of the globe.

Aqueous rocks are all stratified, being sedimentary deposits from water. They originate in the wear of the land by rain, streams, or the waves of the ocean. The débris carried by running water are deposited at the bottom of the seas and lakes, where they are consolidated, and then raised up by subterranean forces, again to undergo the same process of destruction after a lapse of time. By the wasting away of the land the lower rocks are laid bare; and, as the materials are deposited in different places according to their weight, the strata are exceedingly varied, but consist chiefly of arenaceous or sandstone rocks, composed of sand, clay and carbonate of lime. They constitute three great geological divisions, which, in an ascending order, are the primary and secondary fossiliferous strata and the tertiary formations.

The *Primary fossiliferous, or Palæozoic strata,* the most ancient of all the sedimentary rocks, consisting of limestones, sandstones and shales, are entirely of marine origin, having been formed far from land at the bottom of an ocean; consequently they contain the remains of marine animals only, and after the lapse of unnumbered ages even the ripple-marks of the waves are often distinctly visible on the surface of some of their strata. The Palæozoic[2] rocks are divided into Lower Palæozoic and Upper Palæozoic; these again are subdivided into the Laurentian, Cambrian[3] and Silurian;[4] Devonian and old Red Sandstone,

---

[1] See Bischof's 'Chemical Geology' on the subject of Metamorphism.

[2] *Palæozoic* (Gr. παλαιός = 'old,' and ζωή = 'life') *Rocks* are so called in contradistinction to the *Mesozoic* and *Cainozoic*, because they contain the oldest forms of life. They include the lowest division of stratified rocks.

[3] *Cambrian Rocks* were so named by Professor Sedgwick from *Cambria* or Wales, in the north part of which territory they form the lowest rocks visible; they embrace sandstones, slaty shales and conglomerates.

[4] *Silurian Rocks* were so named by Sir Roderick Murchison from the country of the ancient *Silures* where the strata are well developed: they include slates, limestones, sandstones, shales and grit.

Carboniferous, and Permian systems, each of which is distinguished by its peculiar fossil remains.

It was shown by Sir William Logan in Canada, and simultaneously by Sir R. Murchison in the N.W. parts of Scotland, that there exists a sedimentary system of strata of older date than the Cambrian and Silurian rocks. Stratified masses, now for the most part in the state of gneiss, yet containing numerous interpolations of schistose, silicious, calcareous beds, associated with many granitic and hornblendic rocks, are seen in the Laurentian mountains of British North America to rise up from beneath all the Huronian (Cambrian), and Lower Silurian deposits, and hence Sir W. Logan assigned to them the name of *Laurentian*. Discovering a similar infraposition on the West coasts of Sutherland and Ross, including the great island of Lewis, Sir R. Murchison, terming these rocks Fundamental Gneiss, demonstrated that they were clearly overlaid by sandstone and conglomerates, with an entirely different *strike*[1] (Cambrian), and that the latter were followed by crystalline schists and limestone, containing Lower Silurian fossils. The separation of this fundamental or Laurentian gneiss from all the younger schistose, quartzose and occasionally gneissose strata of the central and eastern highlands of Scotland, which are the metamorphosed equivalents of the Silurian rocks, is one of the most important additions to our acquaintance with the history of the succession of geological formation which has been made in the present day.[2]

In the *Cambrian rocks*, estimated by Mr. Aveland at from 23,000 to 28,000 ft. thick, the organic remains include trilobites, phyllopods, brachiopods, and pteropods. The *Silurian* rocks are full of such remains, which abound more and more as the strata lie higher in the series; the whole being characterised by the serrated zoophytes called *Graptolites*. A discovery of animal remains of remarkable interest was made in 1858, in the lowest beds of the Laurentian system, and therefore far beneath the oldest of the hitherto known fossiliferous formations. Dr. Dawson, of Montreal, examining this fossil in 1864 under the microscope, detected in it the structure of a Rhizopod or Foraminifer, and gave it the name of *Eozoon Canadense*.[3] In the *lower Silurian* group

---

1 *Strike* (Ger. *Streichen* = 'to extend') is the *extension* of the strata in a direction at right angles to the *dip*.

2 See 'Quarterly Journal Geological Society;' and 'New Geological Map of Scotland,' by Murchison and Geikie.

3 Herr Otto Hahn concludes, after an extensive examination of ophicalcite or serpentinous limestone, including some undoubtedly genuine eozoonal specimens from Canada, that the structure called eozoon is not

are the remains of shells, almost all of extinct genera; and the few that have any affinity to those alive are of extinct species. *Crinoidea*, or stone lilies, which had been fixed to the rocks like tulips on their stems, are coeval with some of the earliest inhabitants of the deep; and the *trilobite*,[1] a jointed creature of the crab kind, with prominent eyes, is almost exclusively confined to the Silurian strata, but the last traces of it are found in the Carboniferous limestone above. In the upper Silurian group are abundance of marine shells of almost every order, together with crinoidea, vast quantities of corals, and some sea-weeds: several small and very peculiar fishes, of extinct genera, but of a high organisation, have been found in the highest beds—the only vertebrated animals that have yet been discovered among the countless profusion of the lower orders of animals entombed in the primary fossiliferous strata. The remains of one or more land-plants, in a very imperfect state, are said to have been found in the Silurian rocks of North America, which shows that there had been dry land with vegetation at that early period.[2] The type of these plants, as well as the size of the shells and the quantity of the corallines, indicate that a uniformly warm temperature then prevailed over the globe. During the Silurian period an ocean covered the northern hemisphere, islands and lands of moderate size had begun to rise from beneath its waters, and earthquakes, with volcanic eruptions from insular and submarine volcanoes, were frequent towards its close.

The *Upper Palæozoic strata*, which comprise a great geological period, and constitute a principal part of the high land of Europe, were deposited at the bottom of an ocean, like the lower, from the débris of all the others, carried down by water, and still bear innumerable tokens of their marine origin. Calcareous[3] rocks are more abundant in these strata than in the crystalline,[4]

---

organic, and he asserts that the so called canal system can be paralleled in the gneissose rocks of Mont Blanc and the Black Forest. ('Acad.' p. 438, May 6, 1876.)

[1] *Trilobites* (Gr. τρίλοβος = 'three-lobed') include all those species of fossil which have their bodies divided into three lobes by two fissures running parallel to their axes.

[2] According to Sir R. Murchison, the highest authority upon this class of formations, no unequivocal terrestrial plants or vertebral animals (*i.e.* fishes) have been found in strata older than the youngest Silurian, or the Ludlow rocks, where the Silurian begin to pass into the Devonian beds, in which land-plants and fishes abound.

[3] *Calcareous* (Lat. *calx*, *calcis* = 'lime') *Rocks* are so called because they are composed to a large extent of lime.

[4] *Crystalline* is an epithet applied by geologists to such rocks as granite quartzite, marble, &c., which show by their crystalline structure that they

probably because the carbonic acid was then, as it still is, driven off from the lower strata by internal heat, and came to the surface as gas or in calcareous springs, which either rose in the sea and furnished materials for shell-fish and coral animals to build their habitations and form coral reefs, or deposited their calcareous matter on the land in the form of rocks.

The *Devonian and old Red Sandstone group*,[1] in many places 10,000 ft. thick, consisting of strata of conglomerates, dark red, and other sandstones, marls, coralline limestones, &c., forms a link between the Silurian and carboniferous[2] rocks, by a resemblance in their fossil remains. It has fossils peculiarly its own, whilst others are common to the strata both above and below it. There are various species of extinct fishes in this group, some of which were of gigantic size, others had strong bony shields on their heads, and one covered with osseous scales had fins or appendages like wings. The sharks approach nearer to some of these ancient fishes than any other species now living.[3]

During the long period of tranquillity that prevailed after the Devonian group was deposited, a very hot, moist and extremely equable climate, which extended all over the globe, had clothed the islands and lands in the ocean then covering the northern hemisphere with luxuriant tropical forests and jungles. Subsequent inroads of fresh water, or of the sea, or rather partial sinkings of the land, had submerged these forests and jungles, which, being covered with layers of sand and mud, had in time been consolidated into one mass, and were then left dry by the retreat of the waters, or, more probably, raised above the surface by internal forces.

These constitute the remarkable group of the *Carboniferous*

---

have been brought into their present state through the action of chemical forces.

[1] The name of *Devonian* was given to the rocks of this group by Murchison and Sedgwick, because the calcareous strata of Devonshire contain fossils which are unknown in the more arenaceous parts of the old Red Sandstone, and indicate an intermediate period between the Silurian and Carboniferous systems. The Devonian rocks are represented on the Continent by the schistose fossiliferous rocks of the gorges of the Rhine, and in Russia by others containing the shells of Devonshire and the fossil fishes of the old Red Sandstone of Scotland. (See Murchison's 'Siluria.')

[2] *Carboniferous* (Lat. *carbo*='coal,' and *fero*='I bear') is the term generally applied to beds or strata which contain coal.

[3] The old Red Sandstone of Scotland, where it is remarkably well developed, has been admirably illustrated in three works by the late Hugh Miller. (See 'Old Red Sandstone,' the 'Footprints of the Creator,' and 'Testimony of the Rocks.')

system, which consists of strata of limestones, shales and sandstones, filled with a prodigious quantity of the remains of fossil land-plants, intermixed with beds of coal, which is entirely composed of vegetable matter.[1] In some cases the plants appear to have been carried down by floods, and deposited in estuaries near the mouths of rivers; but in most instances the beauty and delicacy of their impressions show that they had grown near to the spot where the coal was formed. More than 300 species of fossil plants have been collected from the strata where they abound, frequently with their seeds and fruits, so that enough remains to show the peculiar nature of this flora, whose distinguishing feature is the preponderance of monocotyledonous[2] plants; among these there were tree-ferns of 40 and 50 ft. high. There were also plants resembling the fox-tail tribe (*equisetum*), of gigantic size; others like the tropical club mosses; besides others, to which we have nothing now living analogous. Coniferous trees of great magnitude, of the pine and fir tribes, flourished at that period. The remains of an extinct araucaria, one of the largest of the pine family, have been found in the British coal-fields; the existing species now grow in countries of the southern hemisphere; a few rare instances occur of grasses, palms and liliaceous plants. The botanical districts were very extensive when the coal-plants were growing, for some species are nearly identical throughout the coal-fields of Europe and America. From the extent of the ocean, the insular configuration of the land, the profusion of ferns and fir-trees, and the warm, moist and equable climate, the northern hemisphere, during the formation of the coal strata, very probably bore a strong resemblance to that of the South Pacific, with its fern and fir clothed lands of New Zealand, Kerguelen Land, &c. &c.

The marine remains of the Carboniferous period are found chiefly in the mountain limestone, a rock which in some countries lies beneath the coal-measures, or sometimes alternates with their shales and sandstones. They consist of crinoidea and marine *testaceæ*,[3] among which the size of the chambered shells, as well as that of the corals, shows that the waters of the ocean were then

---

[1] The total thickness of the coal-measure group is not less than 7000 feet, and it is believed to be in some places even as much as 12,000 feet thick.

[2] *Monocotyledons* (Gr. μόνος = 'one,' and κοτυληδών = 'a cavity') are a class of plants which have but one seed-lobe or cotyledon. They are *endogenous* in growth, as palms, lilies, &c.

[3] *Testaceæ* (Lat. *testa* = 'a shell'), an order of the class *vermes*, according to Linnæus; according to Cuvier, an order of the class *Acephala*, comprising those which are provided with a calcareous shell.

very warm, even in the high northern latitudes. The footsteps of a very large reptile allied to the frog family have been found on some of the Carboniferous strata of North America. In many countries, as in Scotland, Russia and Turkey, the coal-beds are in the Carboniferous limestone.

The coal strata have been very much broken, deranged and dislocated in many places by earthquakes and igneous eruptions, producing faults or dykes, and basaltic veins, which frequently occurred also during the secondary fossiliferous period, and from time to time raised islands and land from the deep. The older rocks are more shattered by earthquakes than the newer, because the movement came from below; but these convulsions have never extended all over the earth at the same time: for example, the Silurian strata have been dislocated and disturbed in Britain, while throughout a vast area in Russia they still retain a horizontal position. There is no proof within the historical period that any entire mountain-chain has ever been raised by great upheavals, although it is generally admitted by our soundest geologists that such took place at remoter periods, with long intervals of ordinary quiescent action, and that by this means the great mountain-ridges of our globe have attained their present position:[1] the contrary opinion, which has for its advocate Sir C. Lyell, will only admit that the elevation has been produced by a long-continued and reiterated succession of small internal movements, with intervals of repose. In some rare instances the land has been raised up or sunk down by an equable motion continued for ages, while in other places the surface of the earth has remained stationary for long geological periods.

The *Permian*[2] *system* of Murchison comes immediately above the coal-measures, and consists of breccias or conglomerates, gypsum, sandstones, marls, &c.; its distinguishing feature in England is a yellow limestone rock, containing a considerable proportion of carbonate of magnesia, which often assumes a granular texture, under which form it is known as Magnesian Limestone or Dolomite. The Permian formation has a flora and fauna peculiar to itself, approaching to those of the coal strata. Here the remnant of an earlier creation gradually tends to its final extinction. The flora is to some extent analogous to that in the coal strata below. Upwards of fifty species of fossil fishes are found in this formation, all

---

[1] Displacement of rocks and elevations of surface are attributed also to the shrinking or contraction of the earth's crust. (See Green's 'Geology,' p. 507.)

[2] The *Permian* system takes its name from the Ancient Russian kingdom of Perm.

belonging to genera known in the Carboniferous epoch; and several *saurian* reptiles,[1] which Owen refers to a higher order than any in the subjacent strata, some of which may have even lived upon dry land.

At the close of the Permian period all the Palæozoic animals disappeared, and an entirely new creation followed in the next series, called the *Trias*,[2] or new red sandstone formation, which lies above the magnesian limestone. In England this formation is particularly rich in rock-salt, which, with beds of gypsum and marl, is from 1000 to 1500 ft. thick; but the Muschelkalk, a peculiar kind of shelly limestone, is wanting, whilst in Germany and on the southern declivity of the Alps it is remarkable for the quantity of its organic remains. At this time creatures like frogs, of enormous dimensions, must have been numerous, as they have left their footsteps on what was then a soft sea-beach. Many genera of fossil animals have been found in the trias in Germany, consisting of shells, cartilaginous fishes, encrinites, &c., all distinct in species, and many in genera, from those of the subjacent magnesian limestone, and also from those entombed in the strata above.

During a long period of tranquillity the *Oolitic*[3] or *Jurassic*[4] group was next deposited in a sea of variable depth, and consists of sands, sandstones, marls, clays, and limestones. At this time there was a complete change in the aqueous deposits all over Europe. The red iron stained arenaceous rocks, the black coal, and dark strata, were succeeded by light-blue clays, pale yellow limestones, and, lastly, white chalk. The water that deposited these strata must have been highly charged with carbonate of lime, since few of the formations of that period are without calcareous matter, and calcareous rocks were formed to a prodigious extent throughout Europe: the Pyrenees, Alps, Apennines, and Balkan abound in them; and the Jura mountains are chiefly formed of them. The European ocean then teemed with animal life; whole beds consisting almost entirely of marine shells and corals. *Belemnites*[5]

---

[1] *Saurian reptiles* are crocodiles, lizards, iguanas, &c.

[2] *Trias* is a continental term, and was borrowed to denominate this period, because in Germany and on the borders of France the rocks deposited during this period formed *three* well-marked groups called the 'Keuper,' 'Muschelkalk' and 'Bunter-Sandstein.'

[3] So called because in the part where they were first examined these rocks comprised many beds of *Oolitic limestone.*

[4] The group was termed *Jurassic* because they compose the *Jura* mountains.

[5] *Belemnites* (Gr. βέλεμνον = 'a dart') are fossil shells which are pointed

and *Ammonites*,[1] from an inch in diameter to the size of a cart-wheel, are entombed by myriads in the strata; whole forests of that beautiful Encrinite, the stone-lily, flourished on the surface of the oolite, then under the waters; and the Pentacrinite, one of the same family, is embedded in millions in the Lias, which occupies extensive tracts in Europe. *Fossil fishes* are numerous in the Oolitic strata, but different from those of the Carboniferous, Permian, and Triassic series. The newly raised islands and lands were clothed with vegetation like that of the large islands of the intertropical archipelagos of the present day, which, though less rich than during the Carboniferous period, still indicate a very moist and warm climate. *Ferns* were less abundant; they were associated with various genera and species of the cycadeæ, which had grown on the S. coast of England, and in other parts of N. Europe, as they now do with the cycas and zamia of the tropics. The pandanus, or screw-pine, the first tenant of new lands in ancient and modern times, belongs to a family found in a fossil state in the inferior Oolite of England, which was but just rising from the deep at that time. The species now flourishing grows only on the coasts of such coral islands in the Pacific as have recently emerged from the waves. In the upper strata of this group, however, the confervæ [2] and monocotyledonous plants become more rare—an indication of a change of climate.

The new lands that were scattered above the ocean of the Oolitic period were drained by rivers, and inhabited by crocodiles and other saurians of gigantic size, mostly of extinct genera. A modern discovery has also shown that birds of a primitive type existed at this epoch. The remains of a strange form, named *Archeopteryx*,[3] were first found in 1861, in the lithographic slate of Solenhofen; in 1862 a nearly perfect skeleton was discovered and added to the collection in the British Museum. The chief peculiarity of this early form of bird is that the tail is elongated as in lizards, consisting of 20 vertebræ, with feathers on each side along the whole length, one pair to each vertebra. The crocodiles

---

like darts, and frequently found in chalk. They are commonly called Thunder stones.

[1] *Ammonites* (Lat. *cornu Ammonis*='horn of Ammon'), are fossil shells related to the nautilus and belonging to the tribe of cuttle fish, or Cephalopods.

[2] *Confervæ* are plants with nearly imperceptible fructification, found in ponds, damp places, and in the sea.

[3] *Archeopteryx* (Gr. ἀρχαῖος='ancient,' and πτέρυξ='wing') the name first given by Herman Von Meyer to the fossil impression of a feather found on the two opposite surfaces of a split slab of the Solenhofen (Oolitic) slate.

of the Oolitic period come nearest to living reptiles; but the others, though bearing a similitude in general structure to recent forms, were quite anomalous, combining in one the structure of various distinct creatures, and so monstrous that they must have been more like the visions of a troubled dream than things of real existence; yet in organisation a few of them came nearer to the type of living mammalia than any existing reptiles do. Some of these had lived in rivers, others in the ocean—some were inhabitants of the land, others were amphibious; and the several species of one genus even had wings like a bat, and fed on insects. There were both herbivorous and predaceous saurians; and from their size and strength they must have been formidable enemies to their neighbours. Besides the numbers deposited are so great, especially in the lias, a marine formation of clay and limestone, which forms the lowest portion of the Oolitic series, that they must have swarmed for ages in the estuaries and shallow seas of the period. They gradually diminished in number towards the end of the secondary fossiliferous epoch; but as a class they lived in all subsequent eras, and some, as the crocodiles, still exist in tropical countries, although the species are very different from their ancient congeners. Tortoises of various kinds—also a family that still exists—were contemporary with the saurians. In the Stonefield slate, a stratum of the Oolitic group, there are the remains of insects, and the bones of 4 small quadrupeds have been found there belonging to the marsupial tribe [1]—a very remarkable circumstance, not only as being the most ancient animal of the class of mammalia, but because that family of animals at the present time is confined to Australia, the two Americas, as far north as Pennsylvania—and higher up in the Oolitic series, in the Purbeck beds of Dorsetshire, as many as 14 species of predaceous and insectivorous mammalia, allied to the beautiful kangaroo rat of Australia. The great changes in animal life are indications of the successive alterations that had taken place during this period on the earth's surface.

The *Cretaceous*[2] *strata* follow the Oolite in the ascending order, consisting of clays, green and Hastings sands, blue limestone, and chalk, probably formed of the débris of coral and shells, which predominates so much in England and other parts of Europe that

---

[1] *Marsupial animals* have pouches in which their young take refuge and are nourished till they attain a certain development. The opossum and kangaroo are marsupials.

[2] *Cretaceous* (Lat. *creta*='chalk,') *strata* are the most recent of the Mesozoic series of rocks, and in England are divided into chalk and green-sand.

it has given the name and its peculiar feature to the whole group. The chalk, however, is by no means universally distributed; it is wanting in many parts of the world where the other strata of this series prevail, and then their connexion with the group can only be ascertained by the identity of their fossil remains. With the exception of some beds of coal in the Oolitic series, the Wealden clay, the lowest of the Cretaceous group in England, is the only freshwater formation, and the tropical character of its flora shows that the climate was still very warm. Plants allied to the zamias and cycadeæ of our tropical regions, many ferns and conifers of the genus araucaria, characterised its vegetation. It was inhabited by tortoises approaching to forms that now live in warm countries, and saurian reptiles of several different genera swarmed in the lakes and estuaries. This clay contains freshwater shells and fish of the carp kind.

The Cretaceous strata above our Wealden clay are full of marine remains. There are vast tracts of sand in N. Europe, and many very extensive tracts of chalk; but in the S. part of the continent the Cretaceous rocks assume a different mineralogical character. There and elsewhere extensive limestone rocks, filled with very peculiar shells, show that, when the Cretaceous strata were forming, an ocean extended from the Atlantic into Asia, which covered the S. of France, all S. Europe, part of Syria, the isles of the Ægean Sea, the coasts of Thrace and the Troad. The remains of turtles have been found in the Cretaceous group, quantities of coral, and abundance of shells of extinct species; some of the most minute species of microscopic shells, or *Foraminifera*,[1] which constitute a large portion of the chalk, have close analogy with creatures now alive, the Globigerinæ, forming the first approach to an identity of species in the ancient and modern creation. An approximation to recent modes of distribution is to be observed also in the arrangement of organised nature, since at this early period, and even in the Silurian and Oolitic epochs, the marine fauna was divided, as now, into distinct geographical provinces. The great saurians were on the decline, and many of them were found no more, but a gigantic creature, allied to the monitor and iguana,[2] lived at this period. From the Trias to the Chalk inclusive only two instances of fossil birds, besides the Archeopteryx, are cited, one in a chalk deposit in the Swiss Alps, and the other, a kind of albatross, in the chalk of England; in North America however, footmarks of a variety of birds have been found in the

[1] *Foraminifera* (Lat. *foramen*='a hole,' and *fero*='I carry'), a class of Protozoa, composed principally of microscopic organisms.

[2] The *monitor* and *iguana*, creatures of the lizard tribe, still existing.

strata between the coal and lias, some of which are larger than those of the ostrich.

With the *Tertiary*, a new order of things may be said to commence, approaching more closely to the actual state of our globe. During the Tertiary period the same causes under new circumstances produced an infinite variety in the order and nature of the strata, accompanied by a corresponding change in animal and vegetable life. The old creation, which had little in common with the existing order of things, had passed away, and given place to one more nearly approaching to that which now prevails. Among the myriads of beings that inhabited the earth and the ocean during the secondary fossiliferous epoch scarcely one species is to be found in the Tertiary. This break in the law of continuity is the more remarkable, as hitherto some of the newly created animals were generally introduced before the older were extinguished. The circumstances and climate suited to the one became more and more unfit for the other, which consequently perished gradually, while their successors increased.[1]

The series of rocks, from the granite to the end of the secondary fossiliferous strata, taken as a whole, constitute the solid crust of the globe, and in that sense are universally diffused over the earth's surface. The Tertiary strata for the most part occupy the hollows formed in this crust, whether by subterraneous movements, by lakes or denudation by water as in the estuaries of rivers, and consequently occur in irregular tracts, often, however, of very great thickness and extent.

The innumerable basins and hollows with which the continents and larger islands had been indented for ages after the termination of the secondary series had sometimes been freshwater lakes, and at other times inundated by the sea: consequently, the deposits which took place during these alternate changes contain the spoils of both terrestrial and marine animals.

There are 3 distinct groups in these strata; the *Lowest Tertiary* or *Eocene*[2] *group*, so called by Sir Charles Lyell, because among the myriads of fossil shell-fish which it contains, very few are identical with those now living; the *Miocene*,[3] or *middle group*,

---

[1] A break in no degree less remarkable than that between the Chalk and the Tertiary strata, exists at the base of the secondary series, between the Permian and the Triassic series.

[2] *Eocene* (Gr. ἠῶς = 'dawn, daybreak,' and καινός = 'new, recent'), a term applied by geologists to the first in point of time of the three subdivisions into which the Tertiary formation is divided and alluding to the approximation in its life to that of the present era.

[3] *Miocene* (Gr. μείων = 'less,' and καινός = 'new, fresh, recent') is a term applied by geologists to the middle division of the Tertiary strata.

has a greater number of the exuviæ of existing species of shells; and the *Pliocene*,[1] or *upper group*, a still larger proportion. Though frequently heaved up to great elevations on the flanks of the mountain chains, as, e.g., in the Alps and Apennines, often assuming a vertical stratification, a part of the Tertiary strata maintain their original horizontal position in the places where they were deposited. Immense insulated deposits of this kind are to be met with all over the world: Europe abounds with them; London, Paris, Rome, and Vienna stand on such strata; and they cover immense tracts both in North and South America.

The gigantic *reptiles* had mostly disappeared, and *mammalia*, of forms scarcely less anomalous, though approaching more nearly to animals now living, took possession of the earth.

Numerous species of extinct animals, of the order of *Pachydermata*,[2] that lived during the Eocene period, and to the greater number of which we have nothing analogous, have been found in various parts of the world, especially in the Paris basin; they were mostly herbivorous quadrupeds, which frequented the borders of the rivers and lakes that covered the greater part of Europe at that time. This is the more extraordinary, as existing animals most similar to them, the tapirs for instance, are confined to the tropical countries. These creatures were widely diffused, and some of them were associated with genera still existing, though of totally different species; such as animals allied to the racoon and dormouse, the ox, bear, deer, fox, dog, &c., &c. Although these quadrupeds differ from those of the present day, the same proportion existed then as now between the carnivorous and herbivorous genera. Remains of *marine mammalia*[3] of this period have also been found, sometimes at great elevations above the sea, all of extinct species; some of these cetacea were of huge size. This marvellous change in the living creation was not confined to the earth and the ocean; the air also was now occupied by many extinct races of birds allied to the owl, buzzard, quail, curlew, &c. The climate must still have been warmer than at present, from the remains of land and sea plants allied to those now growing in equatorial latitudes. Even in England bones of the opossum, monkey, crocodile, and boa have been discovered, animals of warmer latitudes, besides

---

1 *Pliocene* (Gr. πλείων = 'more,' καινός = 'new, recent') is the term applied to the most recent Tertiary deposits in which upwards of 40 per cent. of the fossil shells are of recent species.

2 *Pachydermata* are thick-skinned animals, as the rhinoceros, hog, elephant, tapir, and hippopotamus.

3 *Marine mammalia*, which suckle their young like land animals, are seals, walruses, whales, porpoises, &c.

a sword and saw fish, both genera at present foreign to the British seas.

During the *Miocene period* new amphibious quadrupeds were associated with the old, of which the *Dinotherium*[1] is the most remarkable, and one of the largest of the mammalia yet found, of a singular form, and surpassing the elephant in size.

The *Palæotherium*[2] belonged to this period, and also the huge *Mastodon*.[3] Various families, and even genera, though no species, of quadrupeds now existing were associated with these extraordinary creatures, such as the elephant, rhinoceros, hippopotamus, tapir, horse, bear, wolf, hyæna, weasel, beaver, ox, buffalo, deer, &c.; and also marine mammalia, as seals, dolphins, walruses, and lamantins. Indeed, in the constant increase of animal life manifested throughout the whole of the Tertiary strata, the forms approach nearer to the living ones the higher their remains lie in the series.

In the *older Pliocene* period some of the large amphibious quadrupeds, and other genera of mammalia of the earlier Tertiary periods, cease to appear; but there we find the mastodon, and the Elephas primigenius or mammoth, besides other species of elephant, of prodigious size, which were associated with numerous quadrupeds of existing genera, but lost species. Extinct species of many genera of quadrupeds, now living, inhabited the earth at that time; their bones have been discovered in caverns, enveloped in calcareous breccia or embedded in most of the strata of the epoch—as the hippopotamus, rhinoceros, elephant, horse, bear, wolf, water rat, hyæna, tiger, and several birds. It is remarkable that in Australia the fossil bones all belong to gigantic species of genera of kangaroos and wombats, animals of the marsupial family, which are so peculiarly the inhabitants of that country at the present day. The *newer Pliocene* strata show that the same analogy existed between the extinct and recent mammalia of South America, both, with few exceptions, belonging to that continent alone; for the fossil remains, quite different from those in the old world, are of animals of the same families with the sloths, anteaters, and armadilloes which now inhabit that country, but of vastly superior size. Were changes of species admitted, one might almost fancy that these

[1] *Dinotherium* (Gr. δεινός = 'terrible,' and θηρίον = 'a beast'), a fossil animal of enormous size, remarkable for having set in its under jaw two great elephant-like tusks.

[2] *Palæotherium* (Gr. παλαιός = 'ancient,' and θηρίον = 'beast'), a fossil animal of the tapir kind.

[3] *Mastodon* (Gr. μαστός = 'the breast of a woman,' and ὀδούς, ὀδόντος = 'a tooth'), a fossil animal resembling the elephant, and having conical projections on its molar teeth, from which it has been named.

countries had escaped the wreck of time, and that their inhabitants had dwindled under the change of circumstances. The Megatherium and Equus curvidens, or extinct horse, had so vast a range in America, that while Sir Charles Lyell collected their bones in Georgia in 33° N. latitude, Mr. Darwin brought them from the corresponding latitude in South America. The Equus curvidens differed as much from the living horse as the quagga or the zebra does, and the fossil horse found in Europe is also probably a distinct and lost species.

A comparison of the fossil remains with the living forms has shown the analogy between these beings of the ancient world and those that now people the earth; and the greatest triumph of the naturalist is the certainty with which he can decide upon the nature of animals that have been extinct for thousands of years, from a few bones entombed on the earth's surface. Cuvier will ever be celebrated as the founder of this branch of comparative anatomy, which Professor Owen, in our own country, and following in his steps, has so much extended. Among many other important discoveries, he has found, by microscopic observation, that the structure of the tissue of which teeth are formed is different in different classes of animals, and that the species can in many instances be determined from the fragment of a tooth. A small portion of a bone enabled him to decide on the nature of the extinct race of gigantic birds which formerly inhabited New Zealand, and the subsequent discovery of the entire skeleton confirmed the accuracy of this determination.

The greater part of the continents in the N. hemisphere was elevated above the sea during the Tertiary period, and such lands as already existed acquired additional height; consequently the climate, which had previously been warm and equable, became gradually colder, for an increase of land, which raises the temperature between the tropics, has exactly the contrary effect in higher latitudes. To this cause, and especially to the increase of land in and near the Arctic circle, may be attributed, perhaps, the greater degree of cold that appears to have prevailed during the latter part of the Pliocene period, when a large extent of the European continent was covered by an ocean full of floating ice, not unlike that seen at this day off the N.E. coast of America.[1]

During the latter part of the *Pliocene* period, however, the bed of

---

[1] If a line be drawn from the north-eastern coast of North America within the limit of floating ice, and if it be continued across the southern half of Ireland and England, and prolonged eastward so as to strike against the Ural mountains, it will mark the boundary of the European portion of

that glacial ocean rose partially, and after many vicissitudes the European continent assumed nearly its present form. There is every reason to believe that the glacial sea extended also over great portions of the Arctic lands of Asia and America. Old forms of animal and vegetable life were destroyed by these alterations in the surface of the earth, and the consequent change of temperature; and when, in the progress of the Pliocene period, the mountain tops appeared as islands above the water, they were clothed with the flora and peopled by the animals they still retain; and new forms were added as the land rose and became dry and fitted to receive and maintain the races of animals now alive, all of which had possession of the earth for ages prior to the commonly received historical or human period. Some of the extinct animals had long resisted the great vicissitudes of the times; of these the species of *Elephant* whose remains are found all over Europe, Asia, and America, but especially in the frozen soil of Siberia, alone outlived its associates, the last remnant of a former world. In two or three instances this animal has been discovered entire, entombed in frozen mud, with its hair and flesh so fresh that wolves and dogs fed upon it. The globe of the eye of one found by M. Middendorf at Tas, between the rivers Ob and Yenisei, was so perfect that it is now preserved in the museum at Moscow. It has been supposed that, as the Siberian rivers flow for hundreds of miles from the S. part of the country to the Arctic Ocean, these elephants might have been drowned by floods while browsing in the milder regions, and that their bodies were carried down by the rivers and embedded in mud, and frozen before they had time to decay. Mr. Darwin has suggested that if the climate of Siberia has at any time been similar to that of the high latitudes of South America, where the line of perpetual snow in the Andes, and its sudden flexure in Southern Chile, come close to a nearly tropical vegetation, such a vegetation may have prevailed S. of the frozen regions in Siberia. On the other hand, although the living species of this animal are now inhabitants of the torrid zone, they may have been able to endure the cold of a Siberian winter; for Cuvier has shown that the fossil differed as much from the living elephant as the horse does from the ass. Mr. Darwin supposes that the supply of food in summer was probably sufficient, since the quantity requisite for the maintenance of the larger animals is by no means in proportion to their bulk; or these elephants may have migrated to a more genial climate in the colder months.

---

the glacial sea. It submerged part of Russia to the depth of 1000 ft.—'Essay on the British Fauna and Flora,' by Professor E. Forbes, in the 'Memoirs of the Geological Survey of Great Britain,' vol. i.

Shell-fish seem to have been more able to endure all the great geological changes than any of their organic associates, but they show a constant approximation to modern forms during the progress of the Tertiary period. The whole of these strata contain enormous quantities of shells of extinct species; in the oldest, 5 per cent. of the shells are identical with species now existing, while in the uppermost strata of this great geological period there are not less than from 80 to 95 in 100 identical with those now living in the surrounding seas.[1]

Of all the fossil fishes, from the uppermost Silurian strata to the end of the Tertiary, scarcely one is specifically the same with living forms. In the Eocene strata one-third belong to extinct genera.

Under the vegetable mould in every country there is a mass of loose sand, gravel, and mud, called *alluvium*, lying upon the subjacent rocks, often of great thickness, which in the high latitudes of North America and Europe is mixed with enormous fragments of rock, sometimes angular, and sometimes rounded and water-worn, which have been transported hundreds of miles from their origin. It is known as the *Boulder formation*, or *Northern Drift*: from the identity of its rolled masses with the rocks of the northern mountains, they evidently have been derived from them, and their size becomes less as the distance increases. In Russia there are blocks of great magnitude that have been carried 800 and even 1000 m. in a S.E. direction from their origin in the Scandinavian range. There is reason to believe that these enormous masses were transported by icebergs, and deposited when the N. parts of the continents were covered by the glacial sea, by which part of Russia was submerged to the depth of at least 1000 ft. The same process is now in progress in the high S. latitudes, where icebergs have been met covered with fragments of rock and boulders.[2]

The last manifestation of creative power, with few exceptions, differs specifically from all that preceded it; the recent strata contain only the exuviæ of animals now living, often mixed with the works of man.

The solid earth thus tells us of mountains washed down into the sea with their forests and inhabitants; of lands raised from the

---

1 According to Sir C. Lyell, the Pliocene deposits of England (the Norwich, Red, and Coralline Crags) contain respectively, and in the descending order, 80, 57, and 51 per cent. of species still living, most of which belong to the British seas.

2 Sir James Ross and Captain Wilkes fell in with icebergs covered with mud and stones in the Antarctic seas even in 66′ 5″ lat. One block seen by Sir James Ross was estimated to weigh many tons.

bottom of the ocean, loaded with the accumulated spoils of centuries; of torrents of water and torrents of fire. In the ordinances of the heavens no voice declares a beginning, no sign points to an end; in the bosom of the earth, however, the dawn of life appears, the time is obscurely marked when the first living things moved in the waters, when the first plants clothed the land. There we see that during ages of tranquillity the solid rock was forming at the bottom of the ocean, that during ages it was tossed and riven by fire and earthquake. What years must have gone by since that ocean flowed which has left its ripple marks on the sand, now a solid mass on the mountain—since those unknown creatures left their footprints on the shore, now fixed by time on the rock for ever!—time, which man measures by days and years, nature measures by thousands of centuries.

The thickness of the *Fossiliferous strata* from their first appearance to the end of the Tertiary formation has been estimated at from 7 to 8 m.; so that the time requisite for their deposition must have been immense. Every river carries down mud, sand, or gravel, to the sea: the Ganges and Brahmaputra united are calculated to bring 6,368,077,440 cubic ft. of solid matter every hour into the Bay of Bengal,[1] the Indus 5,866,000,000, and the Mississippi 3,702,758,400; yet notwithstanding these great deposits, the Italian hydrographer Manfredi has estimated that, if the sediment of all the rivers on the globe were spread equally over the bottom of the ocean, it would require 1000 years to raise its bed one foot; so that at that rate it would require 3,960,000 years to raise the bed of the ocean alone to a height nearly equal to the thickness of the fossiliferous strata, or $7\frac{1}{2}$ m., not taking account of the waste of the coasts by the sea itself: but if the whole globe be considered, instead of the bottom of the sea only, the time would be nearly four times as great, even supposing as much alluvium to be deposited uniformly both with regard to time and place, which it never is. Besides, in various places the strata have been more than once carried to the bottom of the ocean, and again raised above its surface after many ages, so that the whole period from the beginning of these primary fossiliferous strata to the present day must be great beyond calculation. These great periods of time correspond wonderfully with the gradual increase of animal life and the successive creation and extinction of numberless orders of being, and with the incredible quantity of organic remains buried in the crust of the earth in every country on the face of the globe.

[1] Lyell, 'Principles of Geology,' 10th Edition, vol. i., pp. 458, 481; Tremenheere, 'Journal of the Royal Geographical Society,' vol. xxxvii. p. 70.

Every great geological change in the nature of the strata was accompanied by the introduction of a new race of beings, and the gradual extinction of those previously existing, their structure and habits being no longer fitted for the altered circumstances in which these changes had placed them. These changes, however, were never abrupt; and it may be observed that there is no proof of progressive development of species by generation from a low to a higher organisation, for animals and plants of high organisation appeared among the earliest of their kind, yet throughout the whole the gradual approach to existing and more perfect forms is undoubted, not by the conversion of one species into another, but by increasing similarity of type.

The *Geographical Distribution* of animated beings was much more extensive in the ancient seas and land than in later times. In very remote ages the same animal inhabited very distant parts of the sea; the corallines built from the equator to within 10 or 15 degrees of the poles; and previous to the formation of the carboniferous strata there appears to have been even a greater uniformity in the vegetable than in the animal world, though Australia had formed even then a peculiar district, supposing the coal in that country to be of the same age as in Europe and America; but as the strata became more varied, species were less widely diffused. Some of the saurians were inhabitants of both the Old and New Worlds, while others lived in the latter only. During the Tertiary period the animals of Australia and America differed nearly as much from those of Europe, as they do at the present day. The globe was then, as it is now, divided into great physical regions, each inhabited by peculiar races of animals; and even the different species of mollusca of the same sea were confined to certain localities. Of more than 400 species of the latter which inhabited the Atlantic Ocean during the early and middle parts of the Tertiary period, little more than a fortieth part were common to the American and European coasts. In fact, the divisions of the animal and vegetable creation into geographical districts had been in the latter periods contemporaneous with the rise of the land, each portion of which, as it rose above the deep, had been clothed with a vegetation and peopled with creatures suited to its position with regard to the equator, and to the existing circumstances of the globe; and the marine creatures had, no doubt, been divided into districts at the same periods, because the bed of the ocean had been subject to similar changes.

The quantity of *Fossil Remains* is so great that, with the exception of the metals and some of the primary rocks, probably not a particle of matter exists on the surface of the earth that has not at some time formed part of a living creature. Since the commence-

ment of animated existence, zoophytes have built coral reefs extending hundreds of miles, and mountains of limestone are full of their remains all over the globe. Mines of shells are worked in some countries to make lime; ranges of hills and rocks, many hundred feet thick, are almost entirely composed of them, and they abound in every mountain chain throughout the earth. The prodigious quantity of microscopic shells discovered by M. Ehrenberg is still more astonishing; some not larger than a grain of sand form plains at the bottom of the ocean and entire mountains above its surface; a great portion of the hills of San Casciano, and of other Tertiary districts in Tuscany, consist of chambered shells so minute that Soldani collected 10,454 from one ounce of stone. Chalk is often almost entirely composed of them.

The facility with which many clays and slates are split is owing, in some instances, to layers of minute shells. Fossil fishes are found in all parts of the world, and in all the fossiliferous strata with the exception of some of the lowest, but each great geological period has species peculiar to itself.

The remains of the great *Saurians* are countless; those of extinct quadrupeds are very numerous; but there is no circumstance in the whole science of Palæontology more remarkable than the multitudes of fossil elephants that are found in Siberia. Their tusks have been an object of traffic in ivory for centuries, and in some places they have lain in such prodigious quantities that the ground is tainted with the smell of animal matter. Their huge skeletons are found from the frontier of Europe through all N. Asia to its extreme E. point, and from the foot of the Altaï Mountains to the shores of the Frozen Ocean, a surface equal in extent to the whole of Europe. Some islands in the Arctic Sea, as, for instance, the Läachow group, are chiefly composed of their remains, mixed with the bones of various other animals of extinct species.[1]

Equally wonderful is the quantity of *fossil plants* that still remain, if it be considered that, from the frail nature of many vegetable substances, multitudes must have perished without leaving a trace behind. The vegetation that covered the terrestrial part of the globe previous to the formation of the carboniferous strata far surpassed in exuberance the rankest tropical jungles at the present day. There are many coalfields of great extent in various parts of the earth, especially in North America, where that of Pittsburg occupies an area of about 14,000 sq. m., and that in the state of Illinois is not much inferior to the area of all England.

---

[1] Lieut. Anjou's 'Polar Voyage.'

As *coal* is entirely a vegetable substance, some idea may be formed of the richness of the ancient flora; in later times it was less exuberant, and never has again been so luxuriant, probably on account of the decrease of temperature during the deposition of the Tertiary strata, and in the glacial period which immediately preceded the creation of the present tribes of plants and animals. Even after their introduction the temperature must have been very low, but by subsequent changes in the distribution of the sea and land the cold was gradually mitigated, till at last the climate of the N. hemisphere became what it now is.

Of late years, well authenticated discoveries have given every reason to believe that a race of mankind peopled various parts of Europe during the post-pliocene period, and were coexistent with the animals of that remote geological era. In the year 1847 M. Boucher de Perthes published an account of flint weapons, evidently the work of man, that he had found mixed with the bones of extinct quadrupeds in an excavation near Abbeville in France, a circumstance that remained unnoticed till subsequent discoveries turned the attention of geologists to the subject. In 1858 Dr. Falconer found implements of human workmanship mixed with the bones of extinct species of quadrupeds in a cavern at Brixham in Devonshire; and during the year 1859 a number of flint hatchets mingled with the bones of extinct animals were dug up by geologists in a post-pliocene deposit that never had been disturbed at St. Acheul near Amiens, and also at Abbeville. Since then numerous other discoveries have been made of unpolished stone implements, buried in ancient river gravels, and in the mud and stalagmite of caves, and associated with remains of the mammoth, the woolly haired rhinoceros, the hippopotamus, the musk ox, and many other quadrupeds of extinct and living species. The river gravels in which these rude implements are found embedded now lie in some places at a height of 100 or even 200 ft. above the present alluvial plains; their antiquity must be measured therefore by the time required for the existing rivers to have scooped out their valleys to this depth, since they were entombed. Still more wonderful is the discovery, since 1864, of these so-called Palæolithic implements in masses of drift, capping the Tertiary strata of the southern coast of Hampshire and the opposite eastern side of the Isle of Wight. Flint tools, exactly resembling those of Abbeville and St. Acheul, have here been found in situations which show that not only certain valleys on the Hampshire coast, but even the channel of the Solent must have been scooped out since man inhabited the district. Remains of human art, in the shape of implements made of stone, bone, and horn, together with mammoth tusks, on which rude carvings exist, were found by Messrs. Lartet,

Christy, and others, in the caverns of Dordogne in central France, which have been decided to belong to a more modern period than the flint implements of the drift. At this epoch the reindeer abounded in the S. of France, implying that a great change of climate has since taken place, although the general outlines of the surface of the country have undergone no alteration.

We have no measure for such remote periods of time; no certain date can be assigned for man's creation; but chronologists have long come to the conclusion that it must have been vastly anterior to the historical period. From the age of Galileo to the present day, the world has been startled from time to time by the results of science; but we may rest assured that they never can be inconsistent with the Scriptures, though they frequently have been with our interpretation of them.

CHAPTER II.

GENERAL VIEW OF THE CONTINENTS.

§ 1. **Direction of the Forces that raised the Continents.**— AT the end of the *Tertiary period* the earth was much in the same state as it is at present with regard to the distribution of land and water. The preponderance of land in the northern hemisphere indicates a prodigious accumulation of internal energy under these latitudes at a very remote geological period. The forces that raised the two great continents above the deep, when viewed on a wide scale, must evidently have acted at right angles to one another, nearly parallel to the equator in the old continent, and in the direction of the meridian in the new; yet the structure of the opposite coasts of the Atlantic points to some connexion between the two.

The *Mountains*, from their rude and shattered condition, bear testimony to repeated violent convulsions similar to modern earthquakes; while the high *Table-lands*, and that succession of terraces by which the continents sink down from their mountain ranges to the plains, to the ocean, and even below it, indicate also that the land must have been heaved up occasionally by slow and gentle pressure, such as appears now to be gradually elevating the coast of Scandinavia and other parts of the earth. The periods in which these majestic operations were effected must have been incalculable, since the dry land occupies an area of from 52,000,000 to 60,000,000 of sq. m.

§ 2. **Proportion of Land and Water.**—The *Ocean* covers nearly three fourths of the surface of the globe, but its distribution is very unequal, whether it be considered with regard to the northern and southern hemispheres, or to the eastern and western. Independently of Victoria Land in the Arctic regions, the extent of which is unknown, the quantity of *Land* in the N. hemisphere is three times greater than that in the southern. In the latter it occupies only one sixteenth of the space between the Antarctic circle and the 13th parallel of S. lat., while between the corresponding parallels in the N. hemisphere the extent of land and water is nearly equal. If the globe be divided into two hemispheres, so that the centre of one shall be a point midway between Pembroke and Wexford, in St. George's Channel, it will be found that one hemisphere contains as much land as water, while in the other the sea exceeds the land in the proportion of nearly 8 to 1. In consequence of this unequal arrangement of the solid and liquid portions of the surface of the earth, England is nearly in the centre of the greatest mass of land, and New Zealand, its antipodes, is in the centre of the greatest mass of water. In fact, only one thirteenth of the land has land directly opposite to it in the opposite hemisphere, and under the equator five sixths of the circumference of the globe is water. But there is still an unexplored region within the Antarctic circle more than twice the size of Europe; and although there is reason to believe that the North Polar basin is an open sea, it has not been navigated. With regard to the land alone, the old continent has an area of about 32,000,000 sq. m., while the extent of America is 15,000,000, and that of Australia with its islands scarcely 3,000,000. Africa is more than 3 times the size of Europe, and Asia is more than 4 times as large. The extent of the continents is 23 times greater than that of all the islands taken together.

The N. polar lands are now well known to a high latitude. Greenland, the domain of perpetual snow, is an immense island, or group of islands, compacted together by ice, so as to resemble one continuous mass of land; and the discovery, by Ross, of an extensive mass of high volcanic land near the south pole is an important event in the history of physical science, though the severity of the climate renders it unfit for the abode of animated beings, or even for the support of vegetable life. It seems to form a counterpoise to the preponderance of dry land in the northern hemisphere. There is something sublime in the contemplation of these lofty and unapproachable regions—the awful realm of ever-during ice and perpetual fire, whose year consists of one day and one night. The strange and terrible symmetry in the nature of the lands within the polar circles, whose limits are to us a blank, where the antagonist

principles of cold and heat meet in their utmost intensity, fills the mind with that awe which arises from the idea of the unknown and the indefinite.

The tendency of the land to assume a peninsular form is very remarkable, and it is still more so that almost all the peninsulas trend to the south—circumstances that depend on some unknown cause which seems to have acted very extensively. The continents of South America, Africa, and Greenland are peninsulas on a gigantic scale, all directed to the south; the peninsula of India, the Indo-Chinese peninsula, those of Korea, Kamstchatka, Florida, California, and Aliaska, in North America, as well as the European peninsulas of Norway and Sweden, Spain and Portugal, Italy, and Greece, observe the same direction. All the latter have a rounded form except Italy, whereas most of the others terminate sharply, especially the continents of South America and Africa, India and Greenland, which have the pointed form of wedges; while some are long and narrow, as California, Aliaska, and Malacca. Many of the peninsulas have an island, or group of islands, near their extremity; as South America, which is terminated by the group of Tierra del Fuego; India has Ceylon; Malacca has Sumatra and Banca; the southern extremity of Australia ends in Tasmania or Van Diemen's Land; a chain of islands runs from the end of the peninsula of Aliaska; Greenland has a group of islands at its extremity; and Sicily lies close to the southern termination of Italy. It has been observed, as another peculiarity in the structure of peninsulas, that they generally terminate boldly in bluffs, promontories, or mountains, which are often the last portions of the continental chains. South America terminates in Cape Horn, a high promontory, which is the visible termination of the Andes; Africa, in the Cape of Good Hope; India, in Cape Comorin, the last of the Ghats; Australia ends in South East Cape, in Tasmania; and Greenland's extreme southern point is the elevated bluff of Cape Farewell.[1]

There is a strong analogy between South America and Africa in form and in the unbroken masses which their surfaces present, while N. America resembles Europe in being much indented by inland seas, gulfs, and bays. Eastern Asia is evidently continued in a sub-aqueous continent from the Indian Ocean across the Pacific nearly to the W. coast of America, of which Australia, the Indian Archipelago, the islands of the Asiatic coast and of Oceania, are the great table-lands and summits of its mountain chains. With

[1] This very general view of the structure of the globe originated chiefly with the celebrated German geologist Von Buch, and has been much extended and developed by M. Elie de Beaumont.

the exception of a vast peninsula in Siberia between the mouths of the rivers Yenisei and Khatanga, and the unknown regions of Greenland, the two great continents terminate in a very broken line to the north; and as they sink beneath the Icy Ocean, the tops of their high lands and mountains rise above the waves, and stud the coast with innumerable snow-clad rocks and islands. The 70th parallel is the average latitude of these northern shores, which have a great similarity on each side of Behring Strait in form, direction, and in the adjacent islands.

§ 3. **Coasts, their extent, and the proportion they bear to the areas of the Continents.**—The peninsular form of the continents adds greatly to the extent of their coasts, which are of such importance to civilisation and commerce. All the shores of *Europe* are deeply indented and penetrated by the Atlantic Ocean, which has formed a number of inland seas of great magnitude, so that it has a greater line of maritime coast, compared with its size, than any other quarter of the world. The extent of coast from the Strait of Waigatz, in the Polar Ocean, to the Strait of Yenikalé, at the entrance of the Sea of Azof, is about 26,700 m. The coast of *Asia* has been much worn by currents, and possibly also by the action of the ocean occasioned by the rotation of the earth from W. to E. On the S. and E. especially it is indented by large seas, bays, and gulfs; and the eastern shores are rugged and encompassed by chains of islands which render navigation dangerous. Its maritime coast is about 36,000 m. in extent.

The coast of *Africa*, 12,560 m. long, is very little broken, except, perhaps, at the Gulf of Guinea and in the Mediterranean. The shores of *North America* have probably been much altered by the Equatorial Current and the Gulf Stream. It is probable that these currents, combined with volcanic action, have hollowed out the Gulf of Mexico, and separated the Antilles, and the Bahama Islands from the continent. The W. coast of North America is less broken, but on the Icy Ocean the coast consists of a labyrinth of gulfs, bays, and creeks. The shores of South America on both sides are very entire, except towards Southern Chile and Cape Horn, where the tremendous surge and the currents of the Ocean in those high latitudes have eaten into the land, and produced endless sounds and fjords which run far into the interior. The whole continent of America has a sea coast of 36,000 m. in extent. Thus it appears that the number of sq. m. of area to 1 m. of coast line is 143 for Europe, 469 for Asia, 895 for Africa, and 350 for America. Hence the proportion is most favourable to Europe, with regard to civilisation and commerce: America comes next, then Asia, and last of all Africa, which has every natural obstacle to contend with, from the extent and nature of its coasts,

the desert character of much of the interior of the continent, and the insalubrity of its climate, on the Atlantic coast at least.

§ 4. **Elevation of the Continents.**—The continents had been raised from the deep by a powerful effort of the internal forces acting under widely extended regions; and the stratified crust of the earth either remained level, rose in undulations, or sank into cavities, according to its intensity. Some thinner portions of the earth's surface, giving way to the internal forces, had been rent into deep fissures; and the mountain masses had been raised by violent concussions, perceptible in the convulsed state of their strata. The centres of maximum energy are marked by the plutonic rocks,[1] which generally form the nucleus or axis of the mountain masses, on whose flanks the stratified rocks are tilted at all angles to the horizon, whence, declining on every side, they sink to various depths, or stretch to various distances in the plains. Enormous as the mountain chains and table-lands are, and prodigious as the forces that elevated them, they bear a very small proportion to the mass of the level continents and to the vast power which raised them even to their inferior altitude. Both the high and the low lands have been elevated at successive periods; some of the very highest mountain chains are of but recent geological date; and some chains that are now far inland once stood up as islands above the ocean, while marine strata filled their cavities and formed around their bases.

§ 5. **Forms of Mountains**; **direction of their Chains.**—Notwithstanding the various circumstances of their elevation, there is everywhere a certain regularity of form in mountain masses, however unsymmetrical they may appear at first sight; and rocks of the same kind have identical characters in every quarter of the globe. Plants and animals vary with climate; but a granite mountain has the same peculiarities in the southern as in the northern hemisphere, at the equator as near the poles. Insulated mountains are rare, and are commonly of volcanic origin. Mountains generally appear in groups intersected in every direction by valleys, and more frequently in extensive chains symmetrically arranged in a series of parallel ridges, separated by narrow longitudinal valleys, the highest and most rugged of which occupy the centre; when the chain is broad, and of the first order in point of magnitude, peak after peak rises in endless succession. The lateral ridges and valleys are constantly of less elevation, and are less bold in proportion to their distance from the central mass, till at last the most remote ridges sink down into gentle undulations. Extensive and

[1] *Plutonic rocks* are granite and others which owe their origin to fire or igneous action.

lofty branches diverge from the principal chains at various angles, and stretch far into the plains. They are often as high as the chains from which they spring, and it happens not unfrequently that these branches are united by transverse ridges, so that the country is often widely covered by a network of mountains; and at the point where these offsets diverge there is frequently a knot of mountains spreading over hundreds of square miles.

One side of a mountain range is usually more precipitous than the other, but there is nothing in which the imagination misleads the judgment more than in estimating the steepness of a declivity. In the whole range of the Alps there is not a single rock which has 1600 ft. of perpendicular height, or a vertical slope of 90°. The declivity of Mont Blanc towards the Allée Blanche, precipitous as it appears to be, does not amount to 45°; and the mean inclination of the Peak of Teneriffe, according to Humboldt, is only 12° 30′. The Silla of Caracas, which rises precipitously from the Caribbean Sea, at an angle of 53° 28′, to the height of between 6000 and 7000 ft., is a majestic instance of, perhaps, the nearest approach to verticality of any great height yet known.

The circumstances of elevation are not the only causes of that variety observed in the summits of mountains. A difference in the composition and internal structure of a rock has a great influence upon its general form, and on the degree and manner in which it is worn by the weather. Thus dolomite assumes generally the form of high, abrupt, and insulated peaks; crystalline schists and gneiss assume the form of needles, as in the Alps; slates and quartziferous schists take the form of triangular pyramids; calcareous rocks a rounded form, or that of table-lands with abrupt declivities; serpentine and trachyte are often of a dome form; *phonolites*[1] assume a pyramidal one; dark walls, like those in Greenland, and of some of our Western Islands of Scotland, are of trap and basalt; and volcanoes are indicated by blunt cones and craters. Thus the mountain peaks often indicate by their form their geological structure.

§ 6. **Connection between the Physical Geography of Countries and their Geological Structure; analogies of the form and contour of Countries.**—Viewing things on a broad scale, it appears that there is also a very striking connection between the physical geography or external aspect of different countries and their geological structure. By a minute comparison of the different parts of the land, M. Boué has shown that similarity of outward

[1] *Phonolite* (Gr. φωνή = 'sound,' and λίθος = 'a stone'), a species of compact homogeneous felspathic rock, sonorous when struck: called also 'clinkstone.'

forms, while indicating similarity in the producing causes, must also to a large extent indicate identity of structure; and therefore, from the external appearance of an unexplored country, its geological nature may be inferred, at least to a certain extent. This he illustrates by pointing out a correspondence, even in their most minute details, between the leading features of Asia and Europe, and the identity of their geological structure. It has been justly observed that, when the windings of our continents and seas are narrowly examined, and the more essential peculiarities of their contours contemplated, it is evident that Nature has not wrought after an indefinite number of types or models, but that, on the contrary, her fundamental types are very few, and derived from the action of definite constructive forces on a primary base.[1] The whole of our land and sea, in fact, may be decomposed into a less or greater number of masses, either exhibiting all these fundamental forms or merely a portion of them. The peninsular structure of the continents, with their accompanying islands, is a striking illustration of the truth of this remark, and many more might be adduced. It follows, as a consequence of that law in Nature's operations, that analogy of form and contour throws the greatest light on the constitution of countries far removed from each other. Even the picturesque descriptions of a traveller often afford information of which he may be little aware.

§ 7. **Interruptions in Continents and Mountain Chains; Table-lands and Plains.**—Continents and mountain chains are often interrupted by posterior geological changes, such as clefts and cavities formed by erosion, as evidently appears from the correspondence of the strata. The chalk cliffs on the opposite sides of the British Channel show that Britain was at one time united to the continent; the formation of the Orkneys and of the N. of Ireland are the same with that of the Highlands of Scotland; so are those on each side of the Strait of Gibraltar; that of Turkey in Europe passes into Asia Minor, the Crimea into the Caucasus; a volcanic region bounds the Strait of Babelmandeb on both sides, and Behring Strait divides the strata of a similar age in the two great continents. Such is also particularly the case with coast islands.

Immediately connected with the mountains are the high table-lands which form so conspicuous a feature in the Asiatic and American continents. These perpetual storehouses of the waters send their streams to refresh the plains, and to afford a highway between nations. Table-lands of less elevation, sinking in terraces of lower and lower level, constitute the links between the

[1] M. Boué.

high ground and the low, the mountains and the plains, and thus maintain the continuity of the land. They frequently are of the richest soil, and enjoy the most genial climate, affording a delightful and picturesque abode to man, though the plains are his principal dwelling. Sloping imperceptibly from the base of the inferior table-lands, or from the last undulations of the mountains, to the ocean, the plains carry off the superfluous waters. Fruitfulness and sterility vary their aspect; immense tracts of the richest soil are favoured by climate and hardly require culture; a greater portion is only rendered productive by hard labour compelling man to fulfil his destiny; while vast regions are doomed to perpetual barrenness, being never gladdened by a shower.

CHAPTER III.

HIGH LANDS OF THE GREAT CONTINENT.

§ 1. **Form of the Great Continent.**—The form of the great continent has been determined by an immense zone of mountains and table-land, lying between the 30th and 45th parallels of north latitude, which stretches across it from W.S.W. to E.N.E. from the coasts of Barbary and Portugal, on the Atlantic Ocean, to Behring Strait, in the North Pacific. North of this lies a vast plain, extending almost from the Pyrenees to the extremity of Asia, the greater portion of which is a dead level, or having low undulations, uninterrupted except by the Scandinavian and British system on the N., and the Ural chain, which is of inconsiderable elevation. The low lands S. of the mountainous zone are much indented by the ocean, and of the most diversified aspect. A great part of the flat country lying between the China Sea and the River Indus is of exuberant fertility, while that between the Persian Gulf and the foot of the Atlas is, with some happy exceptions, one of the most desolate tracts on the earth. The southern lowlands, too, are broken by a few mountain systems of considerable extent and height.

§ 2. **The Atlas, Spanish, French, and German Mountains.**—The *Atlas* and *Spanish mountains* form the western extremity of that great zone of high land that girds the old continent almost throughout its extent: these two mountain systems were at one time united, and from their geological structure, and also the parallelism of their chains, they must have been elevated by forces

acting in the same direction; the Strait of Gibraltar, a sea-filled chasm nearly 500 fathoms deep, now divides them.

A very elevated and continuous mountain region extends in a broad belt along the N.W. of Africa, from the promontory of Ghir, on the Atlantic, to the Gulf of Sidra, on the Mediterranean, embracing all the high land of Morocco, Algiers, and Tunis. It is bounded by the Atlantic and Mediterranean, and insulated from the rest of Africa by the desert of Sahara.

This mountain system consists of three parts. The chain of the *Greater Atlas*, which is farthest inland, extends from Cape Ghir, on the Atlantic, to the Lesser Syrtis; and, in Morocco, forms a group of mountains 15,000 ft. high, covered with perpetual snow.

The *Lesser Atlas* begins at Cape, Spartel (the ancient Cape Cotes) opposite to Gibraltar, and runs parallel to the coast of the Mediterranean till it reaches the Gharian range in Tripoli, the last and lowest of the Little Atlas, which runs in an easterly direction, diminishing gradually in height till it is lost in the plain of the Great Syrtis. That long, rugged, but lower chain of parallel ridges and groups which forms the bold coasts of the Strait of Gibraltar and the Mediterranean, is only a portion of the Lesser Atlas, which, covered with snow, rises above it majestically. The flanks of the mountains are generally clothed with forests, but their summit is one uninterrupted line of bare inaccessible rocks, and they are rent by fissures frequently not more than a few feet wide—a peculiar feature of the whole system.

The *Middle Atlas*, lying between the two great chains, consists of a table-land, rich in valleys and rivers, which rises in successive terraces to the foot of the Greater Atlas, separated by ridges of hills parallel to it. This wide and extensive region has a delightful climate, and abounds in magnificent forests and valleys full of vitality. The Greater Atlas is calcareous in its central portion, and composed of granite and schistose rocks near the sea coast.

The *Spanish peninsula* consists chiefly of a table-land traversed by parallel ranges of mountains, and is surrounded by the sea, except where it is separated from France by the Pyrenees, which extend from the Mediterranean to the Bay of Biscay, and are continued by the Cantabrian chain to Cape Finisterre on the Atlantic.

The *Pyrenean chain* is of moderate height at its extremities, but its summit maintains a waving line whose mean altitude is 8000 ft.; it rises to a greater height on the E.; its highest point is Pic Nethou (11,168 ft.). The snow lies deep on these mountains during the greater part of the year, and is perpetual on the highest parts; but the glaciers, which are chiefly on the northern side, are neither so numerous nor so extensive as those of the Alps.

The greatest breadth of this range is about 60 m., and its length 270. It is so steep on the French side, so rugged, and so notched, that from the plains below its summits look like the teeth of a saw, whence the term Sierra has been appropriated to mountains of this form. On the Spanish side, gigantic sloping spurs or offsets, separated by deep valleys, extend to the banks of the Ebro.

The *interior of Spain* is a table-land with an area of 93,000 sq. m., nearly equal to half of the peninsula. It dips to the Atlantic from its western side, where its altitude is about 2300 ft. There it is bounded by the Iberian mountains, which begin at the W. extremity of the Pyrenees, and run in a tortuous direction S.E. through all the kingdom, constituting the E. boundary of Castile and Murcia, and sending many branches through those provinces to the Mediterranean: its most elevated portion is the Sierra de Moncayo between Calatayud and Tarazona, W. of Saragossa.

The *Cantabrian chain* attains its greatest height in the Peña de Peñaranda (10,910 ft.), where it is composed of rugged peaks of carboniferous limestone.

Four nearly parallel ranges of mountains originate in this limiting chain, running from E.N.E. to W.S.W. diagonally across the peninsula to the Atlantic. Of these the high chain of the Guadarama and the Sierra de Toledo cross the table-land; the W. continuation of the former, the Sierra de los Gredos, contains the Peak of Almanzor, after the peaks Mulahaçen and Nethou, the highest in Spain; the Sierra Morena, so called from the dark colour of its forests on the southern edge; and lastly, the Sierra Nevada, which though only 100 m. long and 50 broad, is the finest range of mountains in Europe after the Alps and Pyrenees, and traverses the plains of Andalusia and Grenada. The table-land is monotonous and bare of trees; the plains of Old Castile are as naked as the Steppes of Siberia; the eastern part is composed of a bare diluvial soil, and uncultivated, except in the valleys of denudation and along the banks of the rivers. Corn and wine are produced in abundance on the widely extended plains of New Castile and Estremadura: other places serve for pasture. The table-land becomes more fertile as it approaches towards Portugal, which is altogether more productive than Spain, though the maritime provinces of the latter on the Mediterranean are beautifully luxuriant, with a semi-tropical vegetation.

Granite and Palæozoic rocks prevail chiefly in the Spanish mountains, and give them their peculiar, bold, serrated aspect; whilst secondary and even tertiary rocks abound in the less elevated ranges, often rising to a very considerable elevation. Some

of the valleys and extensive table-lands between the parallel ranges, through which the great Spanish rivers flow to the Atlantic, appear to have been at one time the basins of lakes.[1]

The mass of high land is continued through the S. of France, at a much lower elevation, by chains of hills and table-lands, the most remarkable of which are the Montagnes Noires, and the great plateau of Auvergne, once the theatre of violent volcanic action, which continued from the beginning to the middle of the Tertiary period, presenting very perfect cones and craters: some of the highest, as the Puy de Dôme, are trachytic domes. The trachytic group of Mont Doré, with its summit, the Puy de Sancy (6,188 ft.), includes an immense crater of elevation.[2] The Cevennes are less elevated: their eastern offsets reach the right bank of the Rhone in the group of the Vivarais. In fact these French mountains are the link between the more elevated masses of Western and Eastern Europe.

The eastern and highest part of the European portion of the mountain zone begins to rise above the low lands about the 52nd parallel of N. latitude, ascending by terraces, groups and chains of mountains, through 6 or 7 degrees of latitude, till it reaches its loftiest point in the great range of the Alps and Balkan. The descent on the S. side of this lofty mass is much more rapid and abrupt, and the immediate offsets from the Alps shorter; but, taking a very general view, the Apennines and mountains of Northern Sicily, those of Greece and the southern part of Turkey in Europe, with those of all the islands of the adjacent coasts, are but outlying members of the general protuberance.

The chains of the Hyrcanian, Sudetes, and Carpathian mountains, form the northern boundary of these high lands; the first, consisting of 3 parallel ridges, extends from the right bank of the Rhine to the centre of Germany, about 51° or 52° of N. lat., with a mean breadth of about 100 m., and terminates in the knot of the Fichtelgebirge, on the confines of Bavaria and Bohemia, covering an area of 9000 sq. m. The Sudetes begin on the E. of this group, and after a circuit of 300 m. round Bohemia, terminate at

---

[1] The physical geography and geology of Spain have received great additions of late years from the researches of M. E. de Verneuil, who has determined barometrically the elevation of many of the most remarkable points, at the same time that he has illustrated the geology of nearly the whole Peninsula in a most masterly manner.

[2] A *crater of elevation* is a mountain, generally of a conical shape, whose top has sunk into a crater or hollow, after the internal force which raised it was withdrawn, but from which no lava had issued. Dome shaped mountains owe their form to internal pressure probably from lava, but which have not again sunk into a cavity or crater.

the small elevated plain of the upper Oder, which connects them with the Carpathian mountains. No part of these limiting ranges attains the height of 5000 ft., except the Carpathians, some of which are very high, and consist of mountain groups united by elevated plains. The highest point is in the S.E. of Transylvania, where Mount Butschetje rises to 9528 ft. The Lomnitzer Spitze in the Tatra group is 8779 ft. The chief Pass across these mountains is the Rothenthurm Pass in the valley of the Aluta. Spurs decline in undulations from these limiting chains towards the great northern plain, and the country to the S., intervening between them and the Alps, is covered with an intricate network of elevations and plains of moderate height.

§ 3. **The Alps, Balkan, and Apennines.**—The *higher Alps*, which form the western crest of the elevated zone, may be said to commence from Cape delle Melle in the Gulf of Genoa, and bend round by the W. and N. to Mont Blanc; then turning E.N.E. they run through the Grisons and Tyrol to the Great Glockner, in 40° 7′ N. lat. and 12° 43′ E. long., where the higher Alps terminate after a course of 420 m. Throughout its whole extent this chain is lofty; many of its peaks rise above the line of perpetual snow; the most elevated part is situated between the Col de la Seigne, on the western shoulder of Mont Blanc, and the Simplon. Some of the highest mountains in Europe are comprised within this space, not more than 60 m. long, including Mont Blanc, which attains an elevation of 15,781 ft. The central ridge of the higher Alps is jagged with peaks, pyramids, and needles of bare and almost perpendicular rock, rising from fields of perpetual snow and rivers of ice to an elevation of 14,000 ft. Many parallel chains and groups, alike rugged and snowy, press on the principal crest, and send their flanks far into the lower grounds. Innumerable secondary branches, hardly lower than the main crest, diverge from it in various directions: of these the chain of the Bernese Alps is the highest and most extensive. It branches off at the St. Gothard from the principal chain, and, running nearly parallel to it, separates the Valais from the Canton of Berne, and with its ramifications forms one of the most remarkable groups of mountain scenery in Europe. Its endless maze of sharp ridges and bare peaks, mixed with gigantic masses of pure snow, presents a scene of sublime quiet and repose, unbroken but by the avalanche and the thunder.

At the Great Glockner the chain of the Alps divides into two branches, forming the Noric and Carnic Alps: the former running towards Vienna, the latter forming the continuation of the principal stem. Never rising to the height of perpetual snow, it separates the Tyrol and Upper Carinthia from Venetia, and, taking

the name of the Julian Alps at Mont Terglou, runs S.E., under various names, till it joins the Eastern Alps, or Balkan, under the 18th meridian. Offsets from this chain cover all the neighbouring countries.

It is difficult to estimate the breadth of the Alpine chain: that of the higher Alps is about 100 m.; it increases to 150 E. of the Grisons, and to 200 between the 15th and 16th meridians, but is not more than 80 at its junction with the Balkan.

The Stelvio (9213 ft.) is the highest carriage pass in these mountains. Those of the Mont Cenis (6772), St. Gothard (6936), Simplon (6595), Splugen (6945), and Ampezzo, go directly over the crest of the Alps. Passes very rarely go over the summit of a mountain; they generally cross a depression between higher peaks, ascending by the valley of a torrent, and descending by a similar depression on the other side.

The frequent occurrence of extensive deep lakes is a peculiar feature in European mountains, rarely to be met with in the Asiatic system, except in the Altaï and on the elevated plains.

With the exception of the Jura, the pastoral region of which is about 3000 ft. above the sea, there are no elevated table-lands in the Alps or European mountains; the tabular form, so eminently characteristic of the Asiatic high lands, begins in the Balkan. The Oriental peninsula rises by degrees from the Danube to Bosnia and Upper Macedonia, which are some hundred feet above the sea: and the Balkan extends 600 m. along this elevated mass, from the continuation of the Dinaric and Julian Alps to Cape Emineh on the Black Sea. It begins by a table-land 70 m. long, traversed by low hills ending, towards Albania and Myritida, in precipitous limestone peaks from 6000 to 7000 ft. high. Rugged mountains, all but impassable, succeed to this, in which the domes and needles of the Schandach, or ancient Scamus, are covered with snow till June. Another table-land follows, whose marshy surface is bounded by mural precipices at Mount Arbelus, near the town of Sophia. There the Hæmus, or Balkan properly so called, commences, and runs in parallel ridges separated by longitudinal valleys to the Black Sea, dividing the plains between the Lower Danube and the Propontis into nearly equal parts. There are few passes in the central ridge, and where there is no lateral ridge the precipices descend at once to the plains.

The *Balkan* is rent by terrific fissures cutting through the chains and table-lands, so deep and narrow that daylight is almost excluded. These chasms afford the safest passes for beasts of burthen. There is but one high road across the chain, viz. that called Trajan's Gate.

The Mediterranean is the southern boundary of the elevated

zone of Eastern Europe, whose last offsets rise in rocky islands along the coasts. The mountains of Sardinia and Corsica may be considered as outlying members of the Maritime Alps, while shorter offsets end in the plains of Lombardy, enclosing the magnificent scenery of the Italian lakes. Even the Apennines, whose chain has given its form to the peninsula of Italy, are but secondary on a greater scale to the broad central band, as well as the mountains and high land in the north of Sicily, which form the continuation of the Calabrian range.

The *Apennines,* beginning where the Maritime Alps terminate, enclose the Gulf of Genoa, and run through the centre of Italy to the middle of Calabria, where they split into two branches, one of which continues to Capo di Leuca, on the Gulf of Taranto; the other to Cape Spartivento, near the Strait of Messina. The whole length is about 800 m. None of the Apennines rise above the line of perpetual snow, though snow lies during nine months of the year on the Monte Corno in the Gran Sasso d'Italia (9591 ft.), in Abruzzo Ulteriore.

Offsets from the Julian and Eastern Alps render Dalmatia and Albania perhaps the most rugged tract in Europe; and the Pindus, which forms the watershed of Greece, diverges from the latter chain, and, running south 200 m., separates Albania from Macedonia and Thessaly.

Greece is a country of mountains, and, although none are perpetually covered with snow, it lies during a great part of the year on several of their summits. The highest point is Mount Guiona in Doris (8239 ft.). The chains terminate in boldly projecting headlands, which reach far into the sea, and reappear in the numerous islands and rocks which stud that deeply indented coast. The Grecian mountains, like the Balkan, are much torn by transverse fractures. The defile of Blatamana and the Gulf of Salonica are examples. The Adriatic, the Dardanelles, and the Sea of Marmora limit the secondary ranges that branch from the southern part of the Balkan.

The valleys of the Alps are deep, long, and narrow; those among the mountains of Turkey in Europe and Greece are mostly caldron shaped hollows, often enclosed by mural rocks. Many of these cavities of great size lie along the foot of the Balkan. In the Morea they are so encompassed by mountains that the water has no escape but through the porous soil, consisting of tertiary strata, some of which have formed the bottom of lakes. Caldron shaped valleys occur also in most volcanic countries, as Italy, Sicily, and central France.

The table-lands which constitute the tops of mountains or of mountain chains are of a different character from those terraces

by which the high lands slope down to the low. The former are on a small scale in Europe, and of forbidding aspect, with the exception of the Jura, which is pastoral, whereas the latter are almost always habitable and cultivated. The mass of high land in S.E. Europe shelves on the N. to the great plain of Bavaria, which is 3000 ft. high; Bohemia slopes downwards from 1500 to 900 ft.; and Hungary from 4000 to 300 above the sea. The descent on the S. side of the Alps is considerably the most rapid, the distance of the plains from the centre of the chain being shorter.

§ 4. **Glaciers.**—It is scarcely possible to estimate the quantity of ice on the Alps: it is said, however, that, independent of the glaciers in the Grisons, there are 1177 sq. m. of glacier in the Alpine range, from 80 to 600 ft. thick. There are no glaciers E. of the Great Glockner, except in the small group of Hallstadt. Thirty four bound the snowy regions of Mont Blanc, covering an area of 1819 m., whilst it is estimated that 95 sq. m. of snow and ice clothe that giant of the chain. Some glaciers have been permanent and stationary in the Alps from time immemorial, while others now occupy ground formerly cultivated or covered with trees, which the irresistible force of the ice has swept away. These ice rivers, formed on the snow clad summits of the mountains, fill the hollows and high valleys, hang on the declivities, or descend by their own gravity through the transverse valleys to the plains, where they are cut short by the increased temperature, and deposit the rocks and rubbish which had fallen upon them from the heights above, forming those accumulations called *moraines*; but their motion is so slow in some instances that generations may pass before a stone fallen on the upper end of a long glacier can reach the terminal moraine. In the Alps the annual rate of motion of the glaciers varies extremely, according to the state of the glacier itself, and of its slope. Rates of motion varying from 14 to 600 ft. annually have been observed. As in rivers, the motion is most rapid in the centre, and slower along the sides and bottom on account of friction. It is slower in winter, although it does not cease, because the winter's cold penetrates the ice, as it does the soil, only to a limited depth. Glaciers are not of solid ice; they consist of a mixture of ice, snow, and water, so that they are in some degree flexible and viscous, acquiring more solidity as they descend to lower levels. Although evaporation goes on at their surface, they are not consumed by it. The terminal front is perpetually melting; it is steep and inaccessible, owing to the configuration of the ground over which it tumbles in its icy cascade, sometimes several hundred feet high. The glacier in its middle course is rather level, the higher part very steep, and the surface

is convex and uneven, and rent by crevices into which the purest blue streams fall in rushing cascades so long as the sun is above the horizon; but they freeze at his setting, and then a deathlike silence prevails. The masses of rocks and large stones that fall on them from the surrounding heights protect the ice below from the sun which melts it all around, so that at last they rest on elevated pinnacles till they fall off by their weight, and in this manner some of those numerous pyramids are formed with which the surface is bristled. Small stones, on the contrary, absorb the sun's heat, and melt the ice under them into holes in which they sink, forming so many small wells. Throughout much of the length of a glacier the winter's snow melts from its surface as completely as it does from the ground; it is fed from above, for in the upper part the snow never melts, but accumulates in a stratified form, and is consolidated. In some of the largest glaciers, where there is a difference in level of some thousands of feet between the origin and termination, the pressure is enormous, and so irresistible as to carry all before it.

Glaciers advance or retire according to the severity or mildness of the season: they have been advancing in Switzerland of late years, but they are subject to cycles of unknown duration. From the moraines, as well as the striæ scratched on the rocks over which they have passed, M. Agassiz considers that the valley of Chamouni was at one time occupied by a glacier that had moved towards the Col de Balme. A moraine 2000 ft. above the Rhone at St. Maurice would appear to indicate that, at a remote period, glaciers had covered Switzerland to the height of 2155 ft. above the level of the Lake of Geneva.

Their increase is now limited by various circumstances—by evaporation at their surface, by blasts of hot air which occur at all heights, but chiefly by the mean temperature of the earth, which, being always above the freezing point in those latitudes, melts the under surface of the glacier, giving rise to a perpetual current, which, united to the natural springs that rise under the frozen mass, and to the rain and melted snow that penetrate through the crevices, forms a stream of turbid water which works out an icy cavern at the extremity of the glacier, and flows from it into the lower ground. Thus a glacier 'begins in the clouds, is formed by the mountains, and ends in the ocean.'[1]

[1] The reader who may wish for a more detailed view on this subject is referred to the writings of Professor Agassiz, and to Professor James Forbes' volumes on Glaciers, a work which is a model of exact observation, combined with such accurate physical and mechanical deductions as could only be arrived at by one eminently conversant with the highest principles of

§ 5. **Geological notice.**—The Crystalline and upper Palæozoic formations are enormously developed in northern Europe; the Secondary and Tertiary are not less so in the central part of the continent; and although the latter continue to be the prevailing strata in the S., they are so much mixed with crystalline rocks that the geology becomes very complicated. Norway, Sweden, Lapland, and Finland are for the most part Crystalline, while the rest of northern Russia belongs to the upper Palæozoic period. Siberia, and a long tract S. of it, are formed of Secondary strata. The whole of southern Russia, to the shores of the Black Sea and Caspian, belongs to the Secondary and Tertiary periods; while tertiary rocks prevail throughout Germany, Denmark, and Holland, to the shores of the North Sea. Metamorphic slates are highly developed in southern and eastern Europe, and form some of the most elevated pinnacles of the Alpine crest and its offsets, of the Caucasus and principal chains in Greece and Turkey in Europe; but the Secondary Fossiliferous strata constitute the chief mass and often rise to the highest summits; indeed, secondary limestones occupy a great portion of the high land of eastern Europe. Calcareous rocks form two great mountain zones on each side of the central chain of the Alps, and rise occasionally to altitudes of 10,000 or 12,000 ft. They constitute a great portion of the central range of the Apennines, and fill the greater part of Sicily. They are extensively developed in Turkey in Europe, where the plateau of Bosnia, with its high lands on the S., part of Macedonia, and Albania with its islands, are principally composed of them.[1] Tertiary strata of great thickness rest on the flanks of the Alps, and rise in places to a height of 5000 ft.; zones of the Pliocene period flank the Apennines on each side, filled with organic remains, and half of Sicily is covered with tertiary strata. With the exception of the islands in the Baltic, and a district S. of the Gulf of Finland, which is Palæozoic, that formation, often mixed with granite, prevails near or along the shores of the Atlantic, but not continuously. A district at North Cape is Palæozoic; the Lofoden Isles are of granite; it again appears in small patches in the Norwegian mountains, which are Palæozoic. The whole of Brittany consists of these two formations, the granite being still more abundant, and stretching diagonally across France in patches, even to the shores of the Mediterranean. But in no part of Europe do the rocks under consideration abound

---

physics and mathematical investigations; and to the later researches of Professor Tyndall, which have modified, on some secondary points, Professor Forbes' views and discoveries.

[1] M. Boué.

so much as on the Atlantic side of the Spanish peninsula: they extend even to the centre of Spain. The Pyrenees are of granite and upper Palæozoic strata, flanked by secondary rocks. Considerable tracts of granite occur in the Moravian, Böhmerwald, and Saxon mountains, but of less importance than those mentioned. It appears that the Atlas, the Sierra Morena, and most of the Spanish mountains, the central chain of the Caucasus, and the Balkan, were raised before the period of the erratic blocks.

From numerous dislocations in the strata the Alps appear to have been heaved up by many violent and repeated convulsions, separated by intervals of repose; and different parts of the chain have been raised at different times. For example, the Maritime Alps and the S.W. part of the Jura mountains were raised previously to the formation of the chalk; but the Tertiary period appears to have been that of the greatest commotions, for nearly two thirds of the lands of Europe have risen since the beginning of that epoch, and those that existed acquired additional height, whilst some have sunk below their original level. During that period the Alps acquired an additional elevation of between 2000 and 3000 ft.; Mont Blanc then attained its present elevation; the Apennines rose 1000 or 2000 ft. higher; and the Carpathians seem to have gained an accession of height since the seas were inhabited by the existing species of animals.[1]

CHAPTER IV.

HIGH LANDS OF THE GREAT CONTINENT—*continued.*

§ 1. **Table-land of Central Asia; Cradle of the Human Race.**—The Dardanelles and the Sea of Marmora form but a small break in the mighty girdle of the old continent, which again appears in immense table-lands, passing through the centre of Asia, of such magnitude that they occupy nearly two fifths of the continent. Here everything is on a much grander scale than in Europe: the table-lands rise above the mean height of the European mountains, and the mountains themselves that gird and traverse them surpass those of every other country in altitude. The most barren deserts are here to be met with, as well as the most luxuriant productions of animal and vegetable life. The earliest records of the human race are found in this cradle of civilisation, and monuments still

[1] Lyell.

remain which show the skill and power of those nations that have passed away, but whose moral influence is still visible in their descendants. Customs, manners, and even prejudices carry us back to times beyond the record of history or even of tradition, while the magnitude with which the natural world is here developed evinces the tremendous forces that must have been in action at epochs immeasurably anterior to the existence of man, remote as that appears to be.

The gigantic mass of high land which extends for 6000 m. between the Mediterranean and the Pacific is 2000 m. broad at its E. extremity, 700 to 1000 in the middle, and somewhat less at its termination. Colossal mountains and elevated terraces form the edges of the lofty plains.

§ 2. **Western Asiatic Table-land.**—Between the 47th and 68th meridians E. long., where the low plains of Hindustan and Bokhara border upon the table-land and reduce its width to 700 or 1000 m., it is divided into two parts by an enormous group of mountains formed by the meeting of the Hindu Kush, the Himalaya, and the Kuen-lun: these two parts differ in height, form, and magnitude.

The western portion, which is the table-land of Persia or plateau of Iran, is oblong, extending from the shores of Asia Minor to the Hindu Kush and the Suliman range, which skirts the W. side of the valley of the Indus. It occupies an area of 633,490 sq. m., generally about 4000 ft. above the sea, and in some places 7000. The Oriental plateau or table-land, much the largest, has an area of 7,600,000 sq. m., its altitude varying from 4000 ft. at Yarkand, to 17,000 ft. in some parts of Tibet.

As the table-lands extend from N.W. to S.E., so also do the principal mountain chains, as well those which bound the high lands as those which traverse them. Remarkable exceptions to this equatorial direction of the Asiatic mass, however, occur in a series of meridional chains, whose axes extend from S.S.E. to N.N.W., between Cape Comorin, opposite to Ceylon, and the Arctic Ocean, under the names of the Western Ghats, the Suliman range, the Kizil Yart (which is the eastern limit of the Pamir plateau), and the Ural Mountains. These chains, rich in gold, lie in different longitudes, and so alternate among themselves that each begins only in that latitude which has not yet been attained by the preceding one. The Khing-han, in China, also extends from S. to N. along the eastern slopes of the table-land of Tartary.[1]

§ 3. **Caucasian Range.**—The lofty range of the Caucasus,

---

[1] Johnston's 'Physical Atlas.'

which extends in an unbroken line 700 m. between the Black and Caspian Seas, is an outlying member of the Asiatic high lands. Offsets diverge like ribs from each side of the central crest, which penetrate the Russian Steppes on one hand, and on the other cross the plains of Kara, or valley of the Kur and Rion, and unite the Caucasus to the table-land. The Caucasus presents much magnificent scenery, and the great peaks shoot up from their bases in unbroken walls of rock and ice. The rivers which drain the N. slopes cut their way through gorges in the limestone, which bars their way down to the vast steppes. Fine forests, far surpassing in extent and richness those of the Alps, clothe the sides of the Caucasus, and reach to an elevation variously estimated at 7300 and 7600 ft. There is a total absence of lakes on both sides of the chain, nor are there any great waterfalls. Some parts of these mountains are very high; Elbruz, on the western border of Georgia, is 18,526 ft. The central portion of the chain, a distance of 120 m. between the peaks of Kasbek (16,545 ft.) to the E., and Elbruz to the W., has been explored by Mr. Douglas Freshfield and a party, and by Mr. F. C. Grove, and others. The glaciers of this part of the chain are very extensive, and, though the snow limit ranges from 10,980 ft. to 12,040 ft., the bases of the great glaciers descend to 7200 ft. The central chain of the Caucasus, according to recent geologists, is chiefly composed of granite; the rocks of both Elbruz and Kasbek are igneous. In addition to these great peaks, the central region contains the elevated summits of Dychtau (16,931 ft.) and Kaschtantau (17,126 ft.) between the two branches of the Tcherek, and several others between 15,000 and 16,000 ft. high. The chief Pass across the range is the Dariel Road, which leads from Mozdok on the N. side to Tiflis on the S. side.

§ 4. **Mountains of Anatolia.**—Anatolia, the most western part of the table-land of Iran, 3000 ft. above the sea, is traversed by short chains and broken groups of mountains, separated by fertile valleys, which sink rapidly towards the Archipelago, and end in promontories and islands along the shores of Asia Minor, which is a country abounding in vast, luxuriant, but solitary plains, watered by broad rivers, in Alpine platforms and mountain ridges, broken up by great valleys, opening seawards with meandering streams. Single mountains of volcanic formation are conspicuous objects on the table-land of Anatolia, which is rich in pasture, though much of the soil is saline, and covered with lakes and marshes. A triple range of limestone mountains, 6000 or 7000 ft. high, divided by narrow but beautiful valleys, is the limit of the Anatolian table-land along the shores of the Black Sea. Two thirds of their height are covered with forests, and broken by

wooded glens, leaving a narrow coast line, except near Trebizond, where it is broad and picturesque. The high land is bounded on the S. by the serrated snowy range of the Taurus, which, beginning in Rhodes, Cos, and other islands in the Mediterranean, fills the S.W. parts of Asia Minor with ramifications; and, after following the sinuosities of the iron bound coast of Karamania in a single lofty range, extends to Samisat, where the Euphrates has cut a passage through this stony girdle.

§ 5. **Mountain region of Armenia, Kurdistan, and Azerbaijan.**—Between the 40th and the 50th meridians the table-land is compressed to nearly half its width; and there the lofty mountainous regions of Armenia, Kurdistan, and Azerbaijan tower higher and higher between the Black Sea, the Caspian, and the Gulf of Scanderoon on the Mediterranean. Here the cold treeless plains of Armenia, the earliest abode of man, 7000 ft. above the sea, bear no traces of the Garden of Eden; Mount Ararat (which the Armenians call *Masis*, the Turks *Ak-Dagh*, and the Persians *Kuh-i-Nuh*, or 'Noah's Mountain') stands a solitary majestic volcanic cone, 16,969 ft. above the sea, shrouded in perpetual snow. Though high and cold, the soil of Armenia is richer than that of Anatolia, and is better cultivated. It shelves on the N. in luxuriant and beautiful declivities to the low and undulating valley of Kara, S. of the Caucasus; and, on the other hand, the broad and lofty mountains of Kurdistan, rising abruptly in many parallel ranges from the plains of Mesopotamia, form its southern face, and spread their ramifications wide over its surface. They are rent by deep ravines, and in many places are so rugged that communication between the villages is always difficult, and in winter impracticable from the depth of snow. The line of perpetual snow is decided and even along their sides; their flanks are wooded, and the valleys populous and fertile.

The brackish Lake Van, which is seldom frozen, though 5120 ft. above the sea, and surrounded by lofty mountains, occupies 1413 sq. m. of Kurdistan.

§ 6. **Persian Mountains.**—The Persian mountains, of which Elburz is the principal chain, extend along the northern brink of the plateau, from Armenia, almost parallel to the shores of the Caspian Sea, maintaining a considerable elevation up to the volcanic peak of Demavend (20,086 ft.), near Tehrân, their culminating point. Elevated offsets of these mountains cover the volcanic table-land of Azerbaijan, one of the most fertile provinces of Persia: there the Koh Savalan elevates its volcanic cone. Beautiful plains, pure streams, and peaceful glades, interspersed with villages, lie among the mountains, and the Vale of Khosran Shah, a picture of sylvan beauty, is celebrated as one of the

five paradises of Persian poetry. The vegetation at the foot of these mountains on the shores of the Caspian has all the exuberance of a tropical jungle. The Elburz decreases in height to the E. of Demavend, and then joins the mountains of Khorasan and the Paropamisan range, which appear to be chains of mountains when viewed from the low plains of Khorasan and Balkh, but on the table-land of Persia they merely form a broad, hilly country of rich soil, till they join the Hindu Kush.

In fact, mountains which bound table-lands have no existence independent of them, being merely their mountainous faces, the highest ranges of which abut on these elevated plains, and rise more or less above them. It is thus that the table-land of Iran is bounded for 1000 m. along the Persian Gulf and Indian Ocean by a mountainous belt of from 3 to 7 parallel ranges, having an average width of 200 m., and extending from the extremity of the Kurdistan Mountains to the mouth of the Indus. The Laristán Mountains, which form the N. part of this belt, and bound the vast level plains of the Tigris, rise from it in a succession of high table-lands divided by very rugged mountains, the last ridge of which, mostly covered with snow, abuts on the table-land of Persia. Oaks clothe their flanks; the valleys are fertile, verdant, and cultivated; and many rivers flow through them to swell the stream of the Tigris. Insulated hill forts, from 2000 to 5000 ft. high, occur in this region, on flat cultivated summits some miles in extent, often accessible only by ladders, or holes cut in their precipitous sides. These countries abound in ancient inscriptions and remains of antiquity. The moisture decreases more and more as we proceed S. from Shiraz; and then the parallel ridges, repulsive in aspect and difficult to pass, are separated by arid longitudinal valleys, which ascend like steps from the narrow shores of the Persian Gulf to the table-land. The coasts of the gulf are burning sandy solitudes, so completely barren that the country from Bassora to the Indus, a distance of 1200 m., is nearly a sterile waste. In a few favoured spots on the terraces, but only where water occurs, there is vegetation; and the beauty of these valleys is enhanced by surrounding sterility.

With the exception of Mazandaran and the other provinces bordering upon the Caspian, and in the Paropamisan range, Persia is an arid region, possessing few perennial springs, and not one great river. In fact, three tenths of the country is a desert, and the table-land is nearly a wide scene of desolation. A great salt desert occupies 27,000 sq. m. between Irak and Khorasan, of which the soil is a stiff clay, covered with efflorescence of common salt and nitre, often an inch thick, varied only by a few saline plants and patches of verdure in the hollows. This dreary waste joins

the large sandy and equally dreary Desert of Kerman. Kelat, the capital of Baluchistan, is 7000 ft. above the level of the sea: round it there is cultivation, but the greater part of that country is a desert plain, over which the brick red sand is drifted by the wind into ridges like the waves of the sea, often 12 ft. high, without a vestige of vegetation. The blast of the desert, whose hot and pestilential breath is fatal to man and animals, renders these dismal sands impassable at certain seasons.

Barren lands or bleak downs prevail at the foot of the Lukee and Suliman ranges, which are formed of bare porphyry and sandstone, and which skirt the eastern edge of the table-land, and dip to the plains bordering on the Indus. In Afghanistan there is little cultivation except on the banks of the streams that flow into the Sistan Lake, but fertility reappears towards the N.E. The plains and valleys among the offsets from the Hindu Kush are of surpassing loveliness, and combine the richest peaceful beauty with the majesty of the snow capped mountains by which they are encircled.

§ 7. **Chain of the Hindu Kush.**—The elevated chain of the Hindu Kush, which occupies the terrestrial isthmus between the low lands of Hindustan and Bokhara, takes its name from a mountain 18,000 ft. above the level of the sea, N. of the city of Cabul. To the W., this chain is very broad, extending over many degrees of latitude, and covering the countries of Kafiristan, Kunduz, and Badakhshan, with its offsets. From the plains to the S. it seems to consist of four distinct ranges rising one above another, the last of which is so high that its snowy summits are visible at the distance of 150 m. A ridge of considerable height encloses the beautiful valley of Kashmir, at the extremity of which the Himalayas may be said to begin. The Passes over the Hindu Kush are mere defiles. There are six from Cabul to the plains of Western Turkistan; and so deep and so much enclosed are they, that Sir Alexander Burnes never could obtain an observation of the pole star during the whole journey from Bamian till within 30 m. of Turkistan.

CHAPTER V.

HIGH LANDS OF THE GREAT CONTINENT—*continued.*

§ 1. **The Table-land of Eastern Asia.**—The great table-land of Eastern Asia extends through 20 degrees of longitude from the sources of the Oxus to those of the Hoang-Ho or Yellow River of China. The height of this enormous protuberance

is small to the N. compared with that of Tibet which forms its summit, the lofty plain of which rises to a mean elevation of about 14,500 ft. above the sea. Tibet is bounded on the S. by the Himalaya, and on the N. by the Kuen-lun. The central part of the plateau, on which are situated Yarkand, Khotan, and other cities, is of much less elevation than Tibet, being from 4000 to 6000 ft. above the sea level. It is bounded on the N. by the Thian-shan or Celestial Mountains; and to the N.E. of these are Mongolia and the Desert of Gobi, which are not more than 4000 ft. above the level of the sea, and are bounded by the mountains that terminate the table-land on the N., separating it from the plains of Siberia. The table-land and all these mountains run nearly from W. to E., nevertheless the Altaï and Himalaya diverge in their eastern course, so that the table-land, which is only 70 or 100 m. wide at its W. extremity, is 1000 between the Chinese province of Yunnan and the country of the Mandchu Tonguses.

This elevated mass of table-lands and mountains ends abruptly in the lofty chain of the Kizil Yart Mountains which divides Eastern from Western Turkistan. West of this range lies the Pamir plateau, which is called by the natives the *Bam-i-Duniah*, or 'Roof of the World.' Its great elevation was made known by the celebrated Venetian traveller Marco Polo, six centuries ago. It forms the watershed of this part of central Asia; the Amu Daria or Oxus issuing from the W. extremity of the small Alpine lake Sir-i-Kol, situated on this elevated plateau, and the rivers of Yarkand and Khokand rising towards the eastern side, which is intensely cold in winter, but in summer is covered with flocks of sheep and goats.[1] From here the table-land of Tibet sinks down by a succession of terraces through the countries of Bokhara and Balkh to the deep cavity in which the Caspian Sea lies. Several Passes lead from the low plains of Western Turkistan to Kashgar and Yarkand on the table-land of Eastern Turkistan.

§ 2. **The Himalayas.**[2]—The Himalaya Mountains run from N.W. to S.E. from the banks of the Indus to the mouth of the Brahmaputra, and along that line there extends the vast unbroken plain of Hindustan, which is prolonged southward to the Bay of Bengal on one hand, while on the other it extends along the foot of the Himalaya, where it is 1200 ft. above the level of the sea.

---

[1] Wood's 'Journey to the Source of the River Oxus.'

[2] Mr. Clements Markham takes a different view altogether of the structure of the Himalayan region from that put forward here by Mrs. Somerville. He regards the system as composed of three great culminating chains—a northern, a central, and a southern chain—which run more or less parallel to one another throughout their whole length, from the gorge of the Indus to that of the Brahmaputra. See his 'Tibet,' introduction, p. xxiii., *et seq.*

The transition from the plain to the mountains is sudden. The Siwalik hills or sub-Himalayan range rise abruptly from the perfectly flat country; their height varies from a few hundred to 3000 or 4000 ft., and they run along the S. edge of the Himalaya from the Indus to the Ganges. They present a steep face towards the plains, while they slope gently inwards and form a shallow valley between them and the next line of mountains, which runs parallel, but at a distance of from 5 to 10 m. This longitudinal depression is broken into short separate valleys by occasional junctions of the parallel ranges of hills. E. of the Ganges it becomes a pestilential swamp, covered with reeds and grasses. It is followed on the N. by a band about 10 m. broad, generally covered by forest and remarkable for want of water. Here a range of mountains 7000 ft. high runs parallel to the Siwalik hills, N. of which lie the well-cultivated valleys of Nepal, Sikkim, Bhutan, and Assam, interspersed with picturesque and populous towns and villages. Behind these again are mountains from 10,000 to 12,000 ft. high, flanked by magnificent forests; and then the chains rise rather abruptly, and form the wonderful range of the elevated Himalaya, the 'Dwelling of Snow,' which surpasses in height all other parts of the earth's surface.

The mean height of the Himalaya is very great (15,670 ft., according to Humboldt). Captain Gerard and his brother estimated that it could not be less than 20,000 ft.; the peaks exceeding that elevation are not to be numbered, especially near the sources of the Sutlej and Ganges. Indeed, from the Ganges to the Kali the chain exhibits an endless succession of some of the loftiest mountains on earth; 40 of them surpass the height of Chimborazo, one of the most celebrated of the Andes, and several in Kumaon and Garhwal exceed 23,000 ft.; but the highest of all—Mount Everest, between Nepal and Sikkim—is 29,002 ft. above the level of the sea according to the measurements of Colonel (now General Sir Andrew) Waugh. The greatest peaks are generally 80 or 90 m. from the southern edge of the chain, and are not found in a continuous ridge, but grouped together in masses separated by deep depressions, through which the streams flow that drain these parts of the mountains. Captain Strachey mentions that in Kanor there is a small tableland the counterpart of Pamir; on both there is a lake 15,000 ft. above the level of the sea, imbedded in mountains 19,000 ft. high, with the same fauna of the domestic yak and wild sheep. The descent to the plains of India is extremely rapid from the tableland, especially in Bhutan, being more than 10,000 ft. in 10 m. The valleys are mere crevices, so deep and narrow, and the mountains that overhang in menacing cliffs so lofty, that these abysses are shrouded in perpetual gloom, except where the rays of a vertical

sun penetrate their depths, and from the steepness of descent the rivers shoot down with the swiftness of an arrow, filling the caverns with foam and the air with mist.

The valleys between the snowy peaks are little more than gigantic ravines, with streams flowing in narrow channels, which at intervals open out into alluvial flats capable of agriculture. After passing the line in which the great peaks are situated, the ascent and the elevation of the bottoms of the valleys become very rapid, which shows that the sudden increase in the height of the mountains in that line is not confined to the peaks, but is a general elevation of the whole mass.

The Himalayan range N. of the Panjab has been described by Mr. Forsyth, as consisting of three parts, the 'outer, mid, and trans-Himalaya.' The outer Himalaya comprises all the low hills, higher slopes and ranges which face the plain of India. Splendid forests of timber and rich vegetation cover these portions almost up to the snow line. The *monsoons*[1] bring rain which washes the hill sides, and the construction of a road is thus rendered very difficult. In the mid-Himalaya vegetation is scant, and there are no forests; glaciers and snowy peaks are everywhere to be seen; snow falls instead of rain, and avalanches are of hourly occurrence. The trans-Himalayan district has mountains of a rounded form, the extreme dryness of the atmosphere preserving the slopes from being cut into ravines. The passes cross by easy ascents and descents from one elevated plain to another.

The *glaciers* in the Himalaya are numerous and very large, yet till comparatively lately they were not supposed to exist. Captain Godwin-Austen of the Indian Trigonometrical Survey, to whom was allotted the rugged district of Baltistan, at the great northern bend of the Upper Indus, examined one glacier, the 'Biafo Ganze,' which was upwards of 60 m. in length, and (in lat. 35°) terminated at an elevation of 10,145 ft. The lowest level to which any is known to descend is 10,000 ft.; but 12,000 ft. is the more usual elevation of their extremities on the S. declivity. On the N. side of the mountains they terminate at about 16,000 ft., and their motion is analogous to that of the glaciers observed in the Alps.

The *snow-line* on the S. of the Himalayan Mountains is at a height of 16,200 ft.; while, on account of the dryness of the atmosphere, it ascends to 17,400 on the N. of the chain.

The Himalaya still maintains great height along the N. of Assam; and where the Brahmaputra cuts through it, the parent

---

[1] *Monsoons* (Fr. *Monson*, *Mousson* = 'a season') are *season winds*; or winds which blow six months from one point of the compass and then six months from the opposite point.

stem and its branches extend in breadth over 2° of latitude; but E. of this point ranges of mountains succeed, having a N. and S. direction, through the narrow valleys between which descend the Irawadi and other rivers of Indo-China lying between the Brahmaputra and the Yang-tsze-Kiang.

Nature has in mercy mitigated the intense rigour of the cold in these high lands in a degree unexampled in other mountainous regions. The climate is mild, the valleys are verdant and inhabited, corn and fruit ripen at elevations which in other countries—even under the equator—would be buried in permanent snow.

It is also a peculiarity in these mountains that, the higher the range, the higher likewise is the limit of snow and vegetation. On the southern slopes of the first range Mr. Gerard found cultivation 10,000 ft. above the sea, though it was often necessary to reap the corn still green and unripe; while in Chinese Tartary crops of barley are raised 16,000 ft. above the sea. Captain Gerard saw pasture and low bushes up to 17,009 ft.; and corn as high as even 18,544 ft., which is 2800 ft. higher than the top of Mont Blanc, and 1279 ft. above the snow line in the province of Quito under the equator. Birch trees with tall stems grow at the elevation of 14,068 ft., and the vine and other fruits thrive in the valleys of these high plains. The temperature of the earth has probably some influence on the vegetation; as many hot springs exist in the Himalaya at great heights, there must be a source of heat beneath these mountains, which in some places comes near the surface. Hot springs abound in the valley of Jumnotra; and as it is well known that many plants thrive in very cold air if their roots are well protected, this may be the cause of pine trees thriving at great elevations in that valley, and of the splendid forests of the Deodar, a species of cedar that grows to a gigantic size even to the verge of the snow line.

Most of the Passes over the Himalaya are but little lower than the top of Mont Blanc; many are higher, especially near the Sutlej, where they are from 18,000 to 19,000 ft. high. The Mustagh is about 18,400 ft., the Karakoram Pass is 18,550 ft., the Yangi, over the Kuen-lun into the plains of Ilchi, is 19,500 ft. All are difficult, but the difficulty is much lessened in the case of the Passes leading from Ladak into Eastern Turkistan, owing to the dryness of the climate. Caravans now cross over Passes from 17,000 to 19,280 ft. in height. On the road from Leh to Yarkand, over the Karakoram, 20 per cent. of the animals die on the road, and for 5 or 6 days neither grass nor fuel is found. But the Chang Chenmo route from Leh to Ilchi, which at one place goes over a Pass 19,000 ft. above the sea, presents no such

difficulties to traders as that over the Karakoram. Grass, wood, and water are found everywhere; and this route, or a modification of it, is likely to be extensively used in conveying Kangra tea and other goods to Yarkand, and reviving a trade which existed for ages before the British occupation of India. Other Passes to the S. and S.W. are not so easy. The Niti, by which Moorcroft ascended to the sacred lakes of Rakas Tal and Mansarowar in Tibet, is extremely difficult. He and his guide had not only to walk barefooted, from the risk of slipping, but they were obliged to creep along the most frightful chasms, holding by twigs and tufts of grass, and sometimes they crossed deep and awful crevices on the branch of a tree, or on loose stones thrown across.

The loftiest peaks, being precipitous, and therefore bare of snow, give great variety and beauty to the scenery, which in these Passes is at all times magnificent. During the day, the stupendous mass of the mountains, their vast extent, the variety and sharpness of their forms, and, above all, the clearness of their distant outline melting into the pale blue sky, contrasted with the deep azure above, is described as a scene of wild and wonderful beauty. At midnight, when myriads of stars sparkle in the black sky, and the pure blue of the mountains looks deeper still, below the white gleam of the earth and snow light, the effect is of unparalleled grandeur, and no language can describe the splendour of the sunbeams at daybreak streaming between the high peaks, and throwing their gigantic shadows on the mountains below. There, far above the habitation of man, no living thing exists, no sound is heard; the very echo of the traveller's footsteps startles him in the awful solitude and silence that reign in these august dwellings of everlasting snow.

On arriving at the table-land by the Niti Pass a traveller finds himself on a wide spreading plain, stretching to the N.W. as far as the eye can reach, without sign of water, vegetation, or animal life. Behind rise mountains that fade away in the distance, with here and there only a peak covered with snow. These mountains are by no means so high as the Himalayas on the S. of the plain, yet they contain the Kailas peaks, 22,068 ft. high, and another 20,500. The plain varies in height from 10,000 to 15,000 ft. above the sea. Moorcroft gives the following account of it: 'In summer the sun is powerful at midday, the air is of the purest transparency, and the azure of the sky so deep that it seems black as in the darkest night. The rising moon does not enlighten the atmosphere, no warning radiance announces her approach till her limb touches the horizon, and the stars shine with the distinctness and brilliancy of suns. In Southern Tibet the verdure is confined to favoured spots; the bleak

mountains and high plains are sternly gloomy, a scene of barrenness not to be conceived. Solitude reigns in these dreary wastes, where there is not a tree nor even a shrub to be seen of more than a few inches high. The scanty short lived verdure vanishes in October: the country looks then as if fire had passed over it, and cutting dry winds blow with irresistible fury, howling in the bare mountains, whirling the snow through the air, and freezing to death the unfortunate traveller benighted in these regions.' This plain consists of two parts: that to the E., which is much encroached upon by mountains, contains the Lakes Rakas Tal and Mansarowar, which lie in a deep recess at the foot of the Gangri Mountains, at an elevation of 15,200 ft. 'The islands and innumerable headlands of the former, the intensely lovely blue of its waters, with its snowy breakers, and Kailas's snowy dome in the background, formed a scene of uncommon beauty, marred, however, by utter desolation and southern blasts that chill to the bone.'

To the W. this desolate plain is much broader and more extensive; it is 15,000 ft. high in its central part, and is cut through by the Sutlej, which issues from the Rakas Tal and flows at the bottom of a deep ravine furrowed out of the alluvial matter of the plain to a depth of 3000 ft. Ravines, the slopes of which are often almost as even and straight as a railway cutting, for miles together intersect this plain of Guge. One mentioned by Captain Strachey is about a mile deep; and their extraordinary magnitude is such that Moorcroft talks of their slopes as mountains overhanging the plain out of which they are cut. Captain Strachey describes Western Tibet as consisting of a dense mass of huge rocky mountains, whose habitable, or even accessible, valleys bear but a small proportion to the solid mass of mountains too steep and high for any human use. The loftier summits rise in all quarters to an elevation of 4 m. above the sea, a few of the highest yet measured are nearly 5 m., and the mean elevation about 20,000 ft. The mountains, however, are by no means disposed in a confused mass; they extend from N.N.W. to S.S.E. in regular parallel chains separated by long valleys, in which flow the upper courses of the Indus and Brahmaputra Rivers. The pundit employed by Captain Montgomerie to execute a reconnaissance survey of this region travelled along the Jong-lam, or great high road, by means of which the Chinese officials keep up their communications between Lhasa and Gartok, N.E. of the Rakas Tal and Mansarowar Lakes. The distance is 800 m., and the average elevation of the road 13,500 ft. above the sea level; only for one stage the road descended so low as 11,000 ft., whilst at several passes it ascended to more than 16,000 ft. The Brahmaputra, which runs

from W. to E., is occasionally crossed by this road, and its waters lie at an elevation of 11,800 ft. at Shigatze, S.W. of Lhasa.

Glaciers are rare in Tibet on account of the dryness of the air, and lie mostly on the N. side of the Himalaya, and on the western part of the Karakoram range, where they are very extensive. But, notwithstanding the severity of the climate, the Tibetans cross the Passes, which are between 18,000 and 19,000 ft. high, even in winter.

§ 3. **The River System of Tibet.**—The river system is one of the principal features of Tibet. The water-parting of the Indus and Brahmaputra is a transverse ridge which runs N. from the Himalaya to the Karakoram, and divides the country into two basins of drainage. The major axes of both rivers lie parallel to the longer axis of the table-land till they attain the extremities of Indian Tibet, where they turn sharply and flow in deep crevices to the plains of India. These two great streams, together with the Sutlej, are the only rivers of Tibetan origin that water the plains of Hindustan; all the rest come from the Himalayan watershed, which is 25 m. to the N. of the line of the great snowy peaks, or from the face of the mountains.

Rain is hardly known in Tibet, and the whole amount of snow that fell during two years that Captain Strachey spent at Leh was little more than 20 inches. The snow does not lie on the arid stony soil. There is a total absence of thunder and lightning, and the air so completely loses its conducting power that a person clothed in sheepskins becomes so highly charged as to give out long sparks on touching a conducting substance.

Even in these elevated regions wheat and barley grow in sheltered places, where there is irrigation, and many of the fruits of S. Europe ripen. Round the villages, barley, peas, and beans are grown; and the eye rests with pleasure on groves of walnut, apricot, mulberry, poplar, and willow. The city of Lhasa in E. Tibet, the residence of the Grand Lama, is surrounded by vineyards, and is called the 'Realm of Pleasure.' There are some trees, but the ground in cultivation in E. Tibet bears a small proportion to the grassy steppes, which extend in endless monotony, grazed by thousands of the shawl-wool goats, sheep, and cattle.

§ 4. **Geology of the Tibetan Mountains; Lakes.**—From the parallelism of the mountain chains in Tibet, that of the line of greatest elevation of the Himalayan peaks, and of the ridge of low hills at their base, Captain Strachey infers that the whole mass has been raised from the bottom of the ocean by one general agency, which is confirmed by its geological structure. The quantity of granite is small, and very rarely expands into moun-

tain masses. Stratified Crystalline rocks, especially gneiss, form the crest of the Himalaya and the mountains in Tibet, and in both Palæozoic beds immediately succeed the Crystalline. But the most remarkable feature of these high lands is, that the plain of Tibet is of comparatively recent origin, consisting of a deposit of boulders and gravel in horizontal strata, rising to an elevation of about 15,000 ft. without any sensible disturbance. In the plain of Guge bones of the elephant, rhinoceros, horse, and a new species of ruminants occur in this deposit; creatures whose existence would be a physical impossibility in the present climate; so that it is necessary to suppose they were elevated from a lower situation by some great geological cataclysm. A very long line of the older fossiliferous rocks about 20 or 30 m. N. of the great Himalayan peaks must have been a sea margin from the earliest period of the earth's history till as late as the Oolitic periods. Tertiary strata occur in the Niti Pass 17,000 ft. above the sea, and even higher still, and probably the plain of Tibet was raised above the sea to its present position since the Tertiary period. There had been a great volcanic outburst near the sacred lakes. Hot springs are frequent both to the S. and N. of the line of great peaks.

There are many lakes in Tibet; that of Pangkong, having an area of 6500 sq. m., lies in a serpentine form at the foot of the Karakoram Mountains, and occupies a valley more than 100 m. long, bounded on the southern side by high, rocky, snow capped mountains, and on the N. by low rounded hills. The waters of the lake are sweet and drinkable at the E. end, but very brackish at the W. end; they are of a deep blue colour, and the hills present every variety of lovely and brilliant colouring. The Pangkong is the most westerly of a system of inland lakes—all new to geographers except Tengri-Nor—which were discovered by the Pundit Nain Sing in his journey of 1874–5, and to which the drainage of the vast river plateau of Tibet converges for a distance of 800 m. Boracic acid exists in abundance in the hot springs of Central Tuscany, and in an extinct crater in the island of Volcano, but Tibet is the only country in the world where native tincal or borate of soda is found.

§ 5. **Eastern Tibet; Provinces of Yarkand and Khotan.**—Of Eastern Tibet much remains to be explored, and the Kuen-lun, which bounds Tibet on the N., is not well known. It extends eastward, perhaps, from the Khotan Darya to the snowy mountains of Gurbu-Naidji, N.W. of the Bukhanor Lake. The Karakoram, or Black Gravel, Mountains, are the most southerly branch, and chains more or less connected with these form an elevated mountain mass round lake Koko-Nor, nearly in the centre of the tableland from whence those immense mountain ranges diverge which

render the S.W. provinces of China amongst the most elevated regions on earth.[1]

Yarkand and Khotan, provinces of E. Turkistan, lie to the N. and N.W. of the Kuen-lun. They are less elevated and more fertile than Tibet; yet it is so cold in winter that the River Yarkand is frozen for three months. The soil is generally sandy and free from stones and rocks. It is very productive; Indian corn, wheat, barley, buck-wheat, and rice grow in perfection; olives, pears, apples, peaches, apricots, mulberries, grapes, currants, and melons are produced of good size and flavour; cotton and raw silk abound. A dense forest stretches for 12 marches between Khotan and Aksu, two of the chief towns. Gold is found in the beds of the streams which flow from the Kuen-lun, and numbers of men are at work on the gold fields. The plains are watered by the Kashgar, Yarkand, Kyzil Kungei, and Khotan Rivers which unite to form the Tarim or Erguo. Several large cities, of which the chief are Yarkand, Khotan or Ilchi, Kashgar, and Aksu, exist. Yarkand, the most considerable of these, is the emporium of commerce between Tibet, China, Turkistan, Bokhara, Persia, and Russia. Gold, rubies, silk, and other productions are exported. This country is bounded on the N. by the Tartar range of the Thian-shan, or Celestial Mountains, which begin N.E. of the Pamir plateau, and, running N.E. between the 40th and 44th parallel N. lat., sink to the Desert of Gobi, about the centre of the table-land; but, rising again, they are continued under the name of Shan-Garjan, which runs to the N.E. and ends on the shores of the Japan Sea. This range is of great altitude; the Bogda Ola, or 'Holy Mountain,' N.E. of Lake Lop, is always covered with snow, which lies deep on the whole chain during the winter, yet little falls on the plains on account of the dryness of the air. There are only two or three showers of rain annually on these mountains, which last for a very short time, and, as in Tibet, the drops are so minute as scarcely to wet the ground, yet the streams from them suffice for irrigation.

In Tibet granite and Palæozoic strata prevail without any indication of volcanic action, except hot springs, of which there are

---

[1] The authorities for the matter contained in this chapter are Humboldt's 'Asie Centrale;' Keith Johnston's 'Physical Atlas;' Captain Strachey's 'Western Tibet;' Moorcroft's 'Journey in Tibet;' Dr. Thomson's 'Western Himalaya;' Dr. Hooker's 'Sikkim and Nepal;' the numerous papers published by the officers of the Trigonometrical Survey of India, under the able direction of Colonel Waugh, and by others in the 'Journal of the Asiatic Society of Calcutta;' the journeys of the missionaries Huc and Gabet in Eastern Tibet; Introduction to Markham's 'Tibet;' 'Journal of Geog. Soc.' for 1875; and 'Geographical Magazine' for June, 1876.

many. The country between the Thian-shan and the Altaï is lakes, swamps, steppes, and deserts, traversed by offsets from the Ala Tau, and Ektag Altaï, and yields some pasturage to the flocks of the wandering Khirgiz. All the plains of Mongolia are intensely cold in winter, because the hills to the N. are too low to screen them from the polar blast, and, being higher than the Siberian deserts, they are bitterly cold: no month in the year is free from frost and snow, yet it is not deep enough to prevent cattle from finding pasture.

§ 6. **Desert of Gobi.**—The most remarkable feature of this part of the table-land is the Desert of Gobi,[1] which is evidently the bed of a dried up lake. It occupies an area of 300,000 sq. m., interrupted only by a few spots of pasture and low bushes. Extensive tracts are flat and covered with small stones or sand, and, widely separated from one another, are low hills destitute of wood and water. Its general elevation is about 4000 ft. above the level of the sea; but it is intersected from W. to E. by a depressed valley, aptly named Shamo, or the 'Sea of Sand,' containing salt. W. from this lies the Han-Hai, the 'Dry Sea,' a barren plain of shifting sand blown into high ridges. Here, as in all deserts, the summer sun is scorching, no rain falls, and when thick fog occurs it is only the precursor of fierce winds. Sandy deserts occupy much of the country S. of the Altaï. The Gobi is bounded on the E. by the In-shan and Khing-han Mountains, a serrated granitic chain running from S. to N., which separates the plateau of Mongolia from the country of Mandchuria, and joins the Yablonnoi branch of the Altaï at right angles about the 55th degree of N. latitude. Little more is known of the S.E. part of the table-land than that it is a mass of exceedingly high mountains. In fact, between the sources of the Brahmaputra and the Altaï chain, 1,000,000 sq. m. of territory are covered with mountains.

The extreme dryness of all the table-land N. of the Himalaya arises from the direction of the winds and the great height of these mountains and the southern part of the table-land in general. The prevailing winds come warm and moist from the Indian Ocean, and their vapour is more and more condensed into rain, as they pass over the plains of India and the lower ranges of the Himalaya, till the last remains of moisture fall in snow on the tops of these mountains, so that they pass to the N. as dry rainless winds.

§ 7. **The Altaï Chain.**—The Altaï Mountains, which form the northern margin of the table-land, are unconnected with the Ural chain: they are separated from it by 400 m. of a low marshy

[1] *Gobi*=literally, a waterless barren plain almost devoid of grass.

country, part of the steppe of the Kirghiz, and by the Dalaï Mountains, a range never exceeding 2000 ft. in height, which runs between the 64th meridian and the left bank of the Irtish. The Altaï chain rises on the right bank of the river, at the N.W. angle of the table-land, and extends in a serpentine line to the Pacific, S. of the Gulf of Okhotsk, dividing the high lands of Tartary and China from the wastes of Asiatic Siberia. Under various names, its branches skirt the N.W. side of the Sea of Okhotsk; and thence stretching to Behring Strait, it ends at East Cape, the most eastern extremity of the old continent, the whole length of the chain being 4500 m. The breadth of this chain varies from 400 to 1000 m., but towards the 105th meridian it is contracted to about 150 by a projection of the Desert of Gobi. Its height bears no proportion to its length and breadth. The Altaï, the only part of the chain properly so called, consists of a succession of terraces of a swelling outline, descending step by step from the table-land, and ending in promontories on the Siberian plains. There are numerous large lakes on these terraces and in the valleys, as in the mountain systems of Europe. The general form of this part of the chain is monotonous from the prevalence of straight lines and smooth rounded outlines—long ridges with flattened summits or small table-lands not more than 6000 ft. high, which rarely attain the line of perpetual congelation; snow, however, is permanent on the Korgon table-land, 9900 ft. above the sea, supposed to be the culminating point of this part of the chain. These table-lands bear a strong resemblance to those in the Scandinavian Mountains in barrenness and sterility, but their flanks are clothed with forests, verdant meadows, and pastoral valleys.

§ 8. **The Sayansk, Tangnou, and Ulangomula Branches; Minerals of the Altaï Range.**—East of the 86th meridian this region of low mountains splits into three branches, enclosing longitudinal valleys for 450 m. The Sayansk and Tangnou Mountains, which are the northern and central branches, form a mountain knot nearly as large as England, which projects like a huge promontory on the Siberian plains W. of Lake Baikal,[1] and is celebrated for the richness of its mines. The third branch, which is the Ulangomula, lies S. of Lake Oubsa. The principal part of the Baikal group is 500 m. long, from 10 to 60 wide, high, and snow capped, and said to be without glaciers. It flanks Lake Baikal on the N., the largest of Alpine lakes, so embedded in a knot of mountains, partly granitic, partly volcanic, that rocks and pillars of granite rise from its bed. The mountains S. of the lake are but

[1] Johnston's 'Physical Atlas.'

the face of the table-land; a traveller ascending them finds himself at once on the Desert of Gobi, which stretches in unbroken monotony to the great wall of China.

The Daouria Mountains, a volcanic portion of the Altaï, which borders the table-land on the N.E., follow the Baikal chain; and farther E., in the centre of the Transbaikal Province, the Altaï range takes the name of the Yablonnoi Khrebet, which runs N.N.E. till about the 126th meridian, where one branch turns sharp to the E., and stretches S. of the Gulf of Okhotsk to the coast of the Pacific opposite to the island of Saghalin; while another part, 1000 m. broad, fills the space between the Sea of Okhotsk and the River Lena, and then, bending to the N.E., ends in the peninsula of Kamtschatka. Between the western end of Lake Baikal and the Yablonnoi Khrebet the mountain chains are parallel, and extend from the W.S.W. to the E.N.E., which is the general direction of the high lands in the most easterly regions of Asia.

A great part of the Altaï chain is unknown to Europeans; especially the innumerable branches that penetrate the Chinese empire; those belonging to Russia abound in a great variety of precious and rare metals and minerals—silver, copper, and iron. In the Yablonnoi range and other parts there are mountains of porphyry, with red and green jasper; coal also is found; and in a branch of the Altaï between the Rivers Ob and Yenisei there are mines of coal which, having been set on fire by lightning, have continued to burn for more than a century. The Siberian mountains far surpass the Andes in the richness of their gold mines, though inferior to those of California and Australia. The eastern flank of the Ural chain, and some of the northern spurs of the Altaï, have furnished a vast quantity of that precious metal; but a region as large as France has been discovered in Siberia, covered with rich gold alluvium. The precious metals of the Ural and Altaï are situated principally in metamorphic rocks, adjacent to the greenstones, syenites, and serpentines that have caused their change; and as the same formation prevails throughout the greater part of the Altaï and Aldan chains almost to Kamtschatka, there is every reason to believe that the whole of that vast region is auriferous: besides, as many of the northern offsets of the Altaï are particularly rich, it may be concluded that the southern branches in the Chinese empire are equally so. Thus S. Siberia and E. Turkistan form an auriferous district, probably greater in area than all Europe, which extends even to our dominions in Hindustan, where the formations containing auriferous deposits are unexplored.[1]

[1] Sir Roderick I. Murchison.

§ 9. **Geological character of the High Lands of the Old Continent.**—The sedimentary deposits in this extensive mountain range are more ancient than the granite, syenite, and porphyries; consequently these igneous rocks have not here formed part of the original crust of the globe. Rocks of the Palæozoic series occupy the greater part of the Altaï, and probably there are none more modern. There are no volcanic rocks, properly speaking, ancient or modern, W. of the Yenisei; but they abound from that river to Kamtschatka, where there are many active volcanoes.

The physical characters and the fossil remains of this extensive mountain system have little relation with the geological formations of Europe and America. Eastern Siberia seems even to form an insulated district by itself; and that part between the town of Yakutsk and the mouth of the Lena appears to have been raised at a later period than the part of Siberia stretching westward to the Sayansk Mountains; moreover, the most distinguished geologists have found that the low land of Siberia has been extended since the existing species of mollusca inhabited the northern seas —a circumstance that must have rendered the Siberian climate still more severe, and materially affected that of all the northern parts of Europe and Asia.[1] The elevation of the western part of the Altaï was probably contemporaneous with that of the Ural Mountains. On the whole, the chains in the direction of the parallels of latitude in the old continent are much more numerous and extensive than those in the direction of the meridian; and as they lie chiefly towards the equator, the internal forces that raised them were probably modified by the rotation of the earth.

Such is the stupendous zone of high land that girds the old continent throughout its whole length. In the extensive plains on each side of it several independent mountain systems rise, though much inferior to it in extent and height.

---

[1] From the observations of Sir Roderick I. Murchison, M. de Verneuil, M. Middendorf, and Count Keyserling.

CHAPTER VI.

SECONDARY MOUNTAIN SYSTEMS OF THE GREAT CONTINENT.

§ 1. **The Scandinavian System; Coast of Norway; Faröe Islands.**—The Great Northern plain is broken by two masses of high land, in every respect inferior to those described; they are the Scandinavian system and the Ural Mountains, the latter forming the arbitrary limit between Europe and Asia.

The range of primary mountains which has given its form to the Scandinavian peninsula begins at Cape Lindesnaes, the most southerly point of Norway, and, after running along its western coast 1000 m. in a N.E. direction, ends at Cape North, the extremity of Europe, on the Polar Ocean. The mountains do not form a continued ridge or chain, but a series of broad plateaux separated at wide intervals by deep and narrow valleys. The most characteristic of these table-lands is the Dovre-fjeld, 3000 ft. high, on which Sneehätten rises to 7566 ft. In the northern and narrower part of the peninsula the Kiolen Mountains assume more the form of a ridge, rising in Mount Sulitelma to 6150 ft. (lat. 67° 30′), whence it falls in the N., till at the North Cape it is only 1500 ft. It has been compared to a huge wave or billow, rising gradually from the E., which, after having formed a crest, falls perpendicularly into the sea in the W. It is estimated that nearly 4000 sq. m. of this peninsula rise above the line of perpetual snow.

At the distance of 360 m. from Cape Lindesnaes the mountains form a single elevated mass, terminated by a table-land which maintains an altitude of 4500 ft. for 100 m. It slopes gradually towards the E., and plunges at once in high precipices into a deep sea on the W.

The surface is barren, marshy, and bristled with peaks; besides, an area of 600 square leagues is occupied by the Snae Braen, the most extensive continuous mass of perpetual snow and glaciers on the continent of Europe. A prominent cluster of mountains follows, from whence a single chain, 25 m. broad, maintains an uninterrupted line to the Island of Mageröe, where it terminates its visible career in North Cape, a huge barren rock perpetually lashed by the surge of the Polar Ocean, but for the correspondence in geological structure it must be continued under the sea to where it reappears in the schistose rocks of Spitzbergen. Offsets from these mountains cover Finland and the low rocky table-land of Lapland;

the valleys and countries along the eastern side of the chain abound in forests and Alpine lakes.

The iron bound coast of Norway is a continued series of rocky islands, capes, promontories, and precipitous cliffs, rent into chasms, which penetrate miles into the heart of the mountains. These chasms, or fjords, are either partly or entirely filled by arms of the sea: in the former case the shores are fertile and inhabited, and the whole country abounds in the most picturesque scenery. Fjords are not peculiar to the coast of Norway; they are even more extensive in Greenland and Iceland, and of a more stern character, overhung by snow clad rocks and glaciers.

As the Scandinavian mountains, those of Faröe, Britain, Ireland, and the N.E. parts of Iceland, have a similar character, and follow the same general directions; they must have been elevated by forces acting in parallel lines, and therefore may be regarded as belonging to the same system.

The Faröe Islands, between Norway and Iceland, rise on a table-land 2000 ft. high, bounded by precipitous cliffs which dip into the ocean.

§ 2. **Mountains of Great Britain and Ireland.**—The two groups of rocky islands of Shetland and of Orkney form part of the mountain system of Scotland; the *Orkney Islands*[1] have evidently been separated from the mainland by the Pentland Firth, where the currents run with prodigious violence. The N.W. part of Scotland is a table-land from 1000 to 2000 ft. high, which ends abruptly in the sea, covered with heath, peat mosses, and pasture. The general direction of the Scottish mountains, like those of Scandinavia, is from N.E. to S.W., divided by a long line of lakes in the same direction, extending from the Moray Firth completely across the island to Loch Linnhe on the S.W. Lakes of the most picturesque beauty abound among the Scottish mountains. The Grampian Hills, with their offsets and some low ranges, fill the greater part of Scotland N. of the Clyde and Forth. Ben Nevis, only 4406 ft. above the sea, is the highest mountain in the British Islands.

The E. coast of Scotland is generally bleak, though in many parts it is extremely fertile, and may be cited as a model of good cultivation; and the midland and southern counties are not inferior, either in the quality of the soil or the excellence of the husbandry. To the W. the country is wildly picturesque; the Atlantic coast, penetrated by the sea, and fringed by islands, bears a strong resemblance to that of Norway.

---

[1] *Orkney Isles* (Gael, *Orc* = 'a whale,' and *innis* = 'an island') = the islands of whales.

There cannot be a doubt that the Hebrides formed part of the mainland at some remote geological period, since they follow the direction of the mountain system in two parallel lines of islands of rugged and imposing aspect, never exceeding the height of 3200 ft. The undulating country on the borders of Scotland becomes higher in the W. of England and N. Wales, where the hills are wild; but the valleys are cultivated like gardens, and the English lake scenery is of the most gentle beauty.

Evergreen Ireland is girdled by mountains, and opposes to the Atlantic storms an iron bound coast of the wildest aspect; but it is rich in arable land and pasture, and possesses the most picturesque lake scenery. Indeed, freshwater lakes in the mountain valleys, so peculiarly characteristic of the European system, are the great ornaments of the high lands of Britain.

§ 3. **Geological Uniformity of the Scandinavian and British Mountain Systems.**—The similarity in form of Scandinavia, and Scotland with its islands, and the N. of Ireland, arises from the similarity in their geological structure, all being formed of crystalline, mixed with volcanic rocks. Even the *lower Palæozoic* strata, which constitute the mountains of Norway, reappear in the midland and southern counties of Scotland, and in the N. of Ireland; and are developed on either side of St. George's Channel, and in Wales, where they are of enormous thickness. Almost the whole of Ireland, and the central parts of England, belong to the *upper Palæozoic* series; and the *Old Red Sandstone,* many hundred feet thick, stretches from sea to sea along the flanks of the Grampians. The *Coal strata* are developed on a great scale in the S. of Scotland and the N. of England. Examples of every formation, except the *muschelkalk,* are to be found in these islands. Volcanic fires had been very active in early times, and nowhere is the columnar structure more beautifully exhibited than in the basaltic cliffs of Fingal's Cave and the Storr of Skye, in the Hebrides; and in the N. of Ireland a base of 800 sq. m. of *mica slate* is covered with volcanic rocks, which end on the coast in the magnificent columnar precipices of the Giant's Causeway. Various parts of the British Islands were dry land while most of the continent of Europe was yet below the ancient ocean. The high lands of Lammermuir and the Grampian Hills in Scotland, and those of Cumberland in England, were raised before the Alps had begun to appear above the waves.

§ 4. **The Ural Chain.**—The Ural chain, between Europe and Asia, is the only interruption to the level of the great northern plain, and is altogether unconnected with, and far separated from, the Altaï Mountains by tundras, plains, and steppes. The central ridge may be traced from between the Lake of Aral and the Cas-

pian Sea to the northern extremity of Novaia Zemlia, a distance of more than 1700 m.; but as a chain it really begins on the right bank of the Ural River, at the steppes of the Kirghiz, about the 51st degree of N. latitude, and runs due N. in a long narrow ridge to the Karskaïa Gulf of the Kara Sea, in the Polar Ocean, though it may be said to terminate in dreary rocks on the W. side of Novaia Zemlia. The southern portion of the Ural range is about the height of the mountains in the Black Forest and the Vosges; and, with few exceptions, it is wooded to the top, chiefly by the Pinus cembra. The great mineral riches of these mountains—gold, platinum, magnetic iron, and copper—are situated on the Siberian declivity, and mostly between 54° and 60° N. lat.: the only part that is colonised, and one of the most industrious and civilised regions of the Russian empire. To the S. the chain is pastoral, about 100 m. broad, consisting of parallel and longitudinal ridges, the highest of which does not exceed 3500 ft.: in this portion diamonds are found. The Northern Ural, which extends from the sources of the Petchora, and N. of Petropaulovsk, is still more elevated: it has been carefully explored by the Russian Government as far as lat. 68° 30′, where is situated the Konstaninow Kamen: the average height is about 3000 ft.; among its loftiest peaks are the Töll Poss (5433 ft.) and Konjakofsky (5397 ft.): no part of the range is covered with perpetual snow, although in the mountains of Norway, in the same latitude, the snow line descends to 3000 ft. Throughout the Ural Mountains there are neither precipices, transverse gorges, nor any of the characteristics of a high chain; the descent on both sides is so gentle that in many places it is difficult to know where the plain begins; and the road over the chain from Russia by Ekaterinburg is so low that it hardly seems to be a mountain Pass. The gentle descent and sluggishness of the streams produce extensive marshes along the Siberian base of the range. Colonel Hoffman found these mountains, on the western side, to be composed of Silurian, Devonian, and Carboniferous rocks, more or less altered and metamorphosed; on the eastern declivity the mines are in metamorphic strata, mixed with masses of igneous origin; and the central axis is of quartzose and chloritic rocks.

§ 5. **The Great Northern Plain.**—The great zone of high land which extends along the old continent from the Atlantic to the shores of the Pacific Ocean divides the low lands into two very unequal parts. That to the N., only broken by the Ural range and the Valdai table-land of still less elevation, stretches from the Thames or the British hills and the N. bank of the Seine to Behring Strait, including more than 190 degrees of longitude, and occupying an area of about 5,300,000 sq. m. at least, a

third more than the whole of Europe. The greater part of it is perfectly level, with a few elevations and low hills, and in many places a dead level extends hundreds of miles. The country between the Carpathian and Ural Mountains is a flat, on which there is scarcely a rise in 1500 m.; and in the steppes of S. Russia and Siberia the extent of level ground is immense. The mean height of the level provinces of France is 480 ft. Moscow, the highest point of the European plain, is also 480 ft. high, from whence the land slopes imperceptibly towards the sea, both on the N. and S., till it dips below its level. Holland, on one side, would be overflowed, were it not for its dykes, and towards Astrakhan the plain sinks still lower. With the exception of the plateau of Ust-Urt (500 to 600 ft.), situated between the Caspian and Lake Aral, and which may be considered the extreme southern point of the Ural chain, the whole of that extensive country N. and E. of the Caspian Sea, and around the Lake of Aral, forms a vast cavity of 18,000 square leagues, all considerably below the level of the ocean; and the surface of the Caspian Sea itself, the lowest point, has a depression of 84 ft.

The European part of the plain is highly cultivated and very productive in the more civilised countries in its western and middle regions and along the Baltic. The greatest amount of cultivated land lies to the N. of the watershed which stretches from the Carpathians to the centre of the Ural chain, yet there are large heaths which extend from the extremity of Jutland through Luneberg and Westphalia to Belgium. The land is of excellent quality to the S. of it. Round Polkova and Moscow there is an extent of the finest vegetable mould, equal in size to France and the Spanish peninsula together, which forms part of the High Steppe, and is mostly in a state of nature.

A large portion of the great plain is pasture land, and wide tracts are covered with natural forests, especially in Poland and Russia, where there are millions of acres of pine, fir, and deciduous trees.

The quantity of waste land in Europe is very great, and there are also many swamps. A morass as long as England extends from the 52nd parallel of latitude, following the course of the River Pripet, a branch of the Dnieper, which runs through its centre. There are swamps at the mouths of many of the sluggish rivers in Central Europe. They cover 1970 sq. m. in Denmark, and mossy quagmires occur frequently in the more northerly parts.

Towards the E. extremity of Europe the great plain assumes the peculiar character of desert called a *steppe*, a word of Sclavonic origin, signifying uncultivated waste land: hence the steppes

may vary according to the nature of the soil. They commence at the River Dnieper and extend along the shores of the Black Sea. They include all the country N. and E. of the Caspian Lake and Independent Tartary; and, passing between the Ural and Altaï Mountains, they may be said to occupy all the low lands of Siberia. Hundreds of leagues may be traversed E. from the Dnieper without variation of scene. A dead level of thin but luxuriant pasture, bounded only by the horizon, day after day the same unbroken monotony fatigues the eye. Sometimes there is the appearance of a lake, which vanishes on approach, the phantom of atmospheric refraction. Horses and cattle beyond number give some animation to the scene, so long as the steppes are green; but winter comes in October, and then they become a trackless field of spotless snow. Fearful storms rage, and the dry snow is driven by the gale with a violence which neither man nor animal can resist, while the sky is clear and the sun shines cold and bright above the earthly turmoil. The contest between spring and winter is long and severe, for

> Winter oft at once resumes the breeze,
> Chills the pale morn, and bids his driving sleets
> Deform the day, delightless.

Yet when gentler gales succeed, and the waters run off in torrents through the channels which they cut in the soft soil, the earth is again verdant. The scorching summer's sun is as severe in its consequences in these wild regions as the winter's cold. In June the steppes are parched, no shower falls, nor does a drop of dew refresh the thirsty and rent earth. The sun rises and sets like a globe of fire, and during the day he is obscured by a thick mist from the evaporation. In some seasons the drought is excessive: the air is filled with dust in impalpable powder, the springs become dry, and cattle perish in thousands. Death triumphs over animal and vegetable nature, and desolation tracks the scene to the utmost verge of the horizon, a hideous wreck.

Much of this country is covered by an excellent but thin soil, fit for corn, which grows luxuriantly wherever it has been sown: but a stiff cold clay at a small distance below the surface kills every herb that has deep roots, and no plants thrive but those which can resist the extreme vicissitudes of climate. A very wide range is hopelessly barren. The country from the Caucasus, along the shores of the Black and Caspian Seas—a dead flat, twice the size of the British Islands—is a desert destitute of fresh water. Saline efflorescences cover the surface like hoar frost. Even the atmosphere is saline, and many salt lakes in the neighbourhood of Astrakhan furnish great quantities of common salt. Saline plants, with patches of verdure few and far between, are the only signs of

vegetable life, but about Astrakhan there is soil and cultivation. Some low hills occur in the country between the Caspian and the Lake of Aral, the desert of Ust-Urt, but it is mostly an ocean of shifting sand, often driven by appalling whirlwinds.

Western Turkistan is a sandy desert, except on the banks of the Oxus, the Zerafshan, and the Jaxartes, and as far on each side of these rivers as canals can convey the fertilising waters. To the N. barrenness gives place to verdure between the River Ural and the mountains of Central Asia, where the steppes of the Kirghiz afford pasture to thousands of camels and cattle, the riches of these wandering hordes.

Siberia is either a dead level or undulating surface of vast extent lying between the North Pacific and the Ural Mountains, the Polar Sea and the Altaï range, whose terraces and offsets end on these plains, like headlands and promontories in the ocean. M. Middendorf, indeed, met with a chain of most desolate mountains on the shores of the Polar Sea, in the country of the Samoiedes; and the almost unapproachable coast far to the E. is unexplored. The mineral riches of the mountains have brought together a population who inhabit towns of some importance along the base of the Ural and Altaï chains, where the soil yields good crops and pasture; and there are forests on the slopes of the mountains and on the plains. There are many hundred square miles of rich black mould covered with trees and grass uninhabited, between the River Tobol and the upper course of the Ob, within a climate where corn would grow; but this valuable district is studded with small lakes of salt and fresh water, a chain of which, 300 m. long, skirts the base of the Ural Mountains.

North of the 62nd parallel of latitude corn does not ripen, on account of the biting blasts from the Icy Ocean which sweep supreme over these unprotected wastes. In a higher latitude even the interminable forests of gloomy firs are seen no more; all is a wide spreading desolation of salt steppes, boundless swamps, and lakes of salt and fresh water. The cold is so intense there that the spongy soil is perpetually frozen to the depth of some hundred feet below the surface; and the surface itself, not thawed before the end of June, is again ice bound by the middle of September, and deep snow covers the ground nine or ten months in the year. Happily gales of wind are not frequent during winter, but when they do occur no living being ventures to face them. Admiral Wrangel, who travelled during the most intense cold from the mouth of the River Kolyma to Behring Strait, gives an appalling account of these deserts. 'Here endless snows and ice covered rocks bound the horizon, nature lies shrouded in all but perpetual winter, life is a constant conflict with privation and with the terrors of cold and

hunger—the grave of nature, which contains only the bones of another world. The people, and even the snow, smoke; and this evaporation is instantly changed into millions of needles of ice, which make a noise in the air like the sound of torn satin or thick silk. The reindeer take to the forest, or crowd together for heat; and the raven alone, the dark bird of winter, still cleaves the icy air with slow and heavy wing, leaving behind him a long line of thin vapour, marking the track of his solitary flight. The trunks of the thickest trees are rent with a loud noise, masses of rock are torn from their sites, the ground in the valleys is rent into yawning fissures, from which the waters that are underneath rise, giving off a cloud of vapour, and immediately become ice. The atmosphere becomes dense, and the glistening stars are dimmed. The dogs outside the huts of the Siberians burrow in the snow, and their howling, at intervals of six or eight hours, interrupts the general silence of winter.'[1] In many parts of Siberia, however, the sun, though long absent from these dismal regions, does not leave them to utter darkness. The extraordinary brilliancy of the stars, and the gleaming snowlight, produce a kind of twilight, which is augmented by the splendid coruscations of the aurora borealis.

The scorching heat of the summer's sun produces a change like magic on the southern provinces of the Siberian wilderness. The snow is scarcely gone before the ground is covered with verdure, and flowers of various hues blossom, bear their seed, and die in a few months, when winter again resumes its empire. A still shorter lived vegetation scarcely covers the plains in the far north, and, on the shores of the Icy Sea, even reindeer moss grows scantily.

The abundance of fur bearing animals in the less rigorous parts of the Siberian deserts has tempted the Russians to colonise and build towns on these frozen plains. Yakutsk, on the River Lena, in 62° 1′ 30″ N. lat., is probably the coldest town on the earth. The ground is perpetually frozen to the depth of more than 400 ft., of which 3 ft. only are thawed in summer, when the thermometer is frequently 77° in the shade; but, as there is in some seasons no frost for four months, larch forests cover the ground, and wheat and rye produce from fifteen to forty fold. In winter the cold is so intense that mercury is constantly frozen for two months, and occasionally even for three.

[1] In 1820 Admiral (then Lieutenant) Wrangel travelled from the mouth of the Kolyma to Behring Strait on sledges drawn by dogs, and made a bold, but vain, attempt to reach the North Pole. Lieutenant Anjou, at the same time, sailed from the mouth of the River Tana, reached 76° 30′ of north latitude, and passed round the group of islands of New Siberia.

CHAPTER VII.

THE SOUTHERN LOW LANDS OF THE GREAT CONTINENT.

§ 1. **The Climatic Character of the Southern Low Lands.** —The low lands to the S. of the great mountain girdle of the old continent are much broken by its offsets, by separate groups of mountains, and still more by the deep indentations of bays and large seas. Situated in lower latitudes, and sheltered by mountains from the cutting Siberian winds, these plains are of a more tropical character than those to the N.; but they are strikingly contrasted in their different parts—either rich in all the exuberance that heat, moisture, and soil can produce, or covered by wastes of bare sand —in the most advanced state of cultivation, or in the wildest garb of nature.

The barren parts of the low lands lying between the eastern shores of China and the Indus bear a small proportion to the riches of a soil vivified by tropical warmth and watered by the periodical inundations of the mighty rivers that burst from the icy regions of Tibet and the Himalaya. On the contrary, the favoured regions in that part of the low lands lying between the Persian Gulf, the Euphrates, and the Atlas Mountains, are small when compared with the immense expanse of the Arabian and African deserts scorched by a tropical sun. The blessing of a mountain zone, pouring out its everlasting treasures of moisture, the life blood of the soil, is nowhere more strikingly exhibited than in the contrast formed by these two regions of the globe.

§ 2. **The Tartar Country of Mandchuria; Russian Colonisation on the Amur.**—The Tartar country of Mandchuria, watered by the southern tributaries of the Amur, is a varied region of wooded mountains and fertile river valleys, bounded on the W. by the moving sands of the Gobi Desert.

The Russians, by gradual encroachments, were virtually in possession of this country before the Chinese war of 1860; but the district of the Amur (Amurskaya), together with an extensive region along the coast to the S., bounded, on the W., by the Usuri, and on the S. by the River Tumen, was ceded to them by treaty. By this cession Russia obtained a harbour (Possiet Bay) in lat. 42° 30′, in the Sea of Japan, which is open to vessels nearly all the year round, and thus possesses great advantage over Nicolaievsk at the mouth of the Amur, which is closed by ice for 5 months in the year. A little to the N. of Possiet Harbour is Guèrin Gulf, from which, by means of the Suifun and Lefu Rivers, there is water

communication (with a portage of only a few miles) from these southern possessions to the Usuri River, which latter is navigable by steam vessels nearly its whole length into the Amur. In this extensive country there are now 43,000 Russian colonists, and the whole population amounts to 44,400, spread over an area of about 172,892 sq. m. Near the coast stretches the range of the Sikhota Alin Mountains, and the country possesses forests of valuable timber; but there are areas capable of feeding thousands of cattle, and of producing European grains to an unlimited extent. In the N., the mountains of the Upper Amur abound in fine forests of oak, and are rich in gold, silver, and iron. Gold is found in all the tributaries of the Amur that have their sources in these mountains; but mining operations are limited to about 4 months, on account of the severity of the climate.

The Kirghis occupy a region of Central Asia lying between Siberia and the northern provinces of China that consists of vast steppes or plains, of which the sandy Desert of Gobi is the most extensive. They are luxuriant with grass and wild flowers for a few weeks in spring, when they are covered with innumerable groups of herds and flocks, which, although numbered by tens of thousands, appear only like spots on these all but boundless plains. In summer, whirlwinds sweep over the withered grass of this burning waste, and clouds of dust suffocate both man and beast; in winter, icy gales of irresistible fury blind with snow and freeze to death. Then the inhabitants take shelter with their flocks and herds in villages, or groups of dwellings, which are something between huts and tents. They are the descendants of a race of conquerors; many of their chiefs trace their descent from Tamerlane, others from Genghis Khan; they are dignified and brave, and are daring horsemen.

Such are the people that the Russians have now brought into subjection, and have surrounded by fortified settlements, in order to add to the warlike population of the empire some hundred thousand horsemen whose military spirit and power of endurance are probably unequalled. They have already got possession of a large territory containing silver mines of immense value in exchange for some gaudy trifling ornaments. Thus within a few years Russia has extended her boundaries southwards to the Oxus and the Kara Tau Mountains, and added to her enormous empire a territory exceeding in extent France, Spain, and Italy, rich beyond expression in the precious metals, iron, and coal, and including all the great lines of communication on which the commerce between the east and the west depended. Already the foundries furnish the Russian steam navy in the North Pacific with guns and machinery, and they expect in a short time to super-

sede the British manufactures in all kinds of cutlery and muskets. The Russians will probably go on enlarging their borders in this direction until they touch the British frontiers; and such is the activity and skill with which that people improve their advantages, that it will require all the enterprise of our merchants, and that of the other European nations, and the superior quality of their goods, to prevent Russia from obtaining the entire and exclusive commerce of Eastern Asia.[1]

In the Corea there are cultivated plains at the base of its central mountain range.

§ 3. **Plain of China; Emigration of Chinese to British Colonies.**—China is the most productive country on the face of the earth; an alluvial plain of 210,000 sq. m., formed by one of the most extensive river systems in the old world, occupies its eastern part. This plain, 7 times the size of Lombardy, is no less fertile, and well irrigated by canals. The Great Canal traverses its eastern part for 700 m., of which 500 are in a straight line of considerable breadth, with a current in the greater part of its course. Most of the plain is laid out in rice and garden grounds, the whole cultivated with the spade. The tea plant grows on low hills between 30° and 32° N. lat., offsets from the Pe-ling chain. The cold in winter is much greater than in corresponding latitudes in Europe, and the heat in summer is proportionally excessive.

Notwithstanding the great fertility of China, and the extent of arable land, the people are always pressed for the means of subsistence, and they never were more so than now when the population amounts to 405,000,000; hence emigration is going on to a large extent to Australia, California, and even the Antilles. Queen Victoria has at present at Hong Kong, in her Malayan colonies, and in Australia, more than a quarter of a million of Chinese subjects. This singular people, more laborious and ingenious than the most civilised of the Asiatic nations, is so much addicted to commercial intercourse with strangers that it will depend upon ourselves to improve it to the best advantage. The Russians have had for many years a religious establishment at Pekin, but of late there have been attached to it men of science, miners, geologists, and astronomers, by whose observations it appears that China abounds in Palæozoic rocks with many ores and metals, vast and rich coal fields, and, with a most productive soil, forms a wondrous mine of wealth, which, when opened out to Europeans, may operate greater

[1] The Khanate of Khokand was absorbed into the Russian empire in March 1876, and formed into a new government called Ferghana.

changes in our international relations than all the gold of California, Australia, or British Columbia.[1]

§ 4. **Physical Features of the Indo-Chinese Peninsula.**—The Indo-Chinese peninsula, lying between China and the Brahmaputra River, has an area of 77,700 sq. m., and projects 1300 m. into the ocean. Several parallel chains of great length detach themselves from the eastern extremity of the Himalaya, and form a number of deep valleys through which flow the upper waters of the great rivers of this region. They extend in a southerly, but diverging, direction, and spread like the spokes of a fan through the Indo-Chinese peninsula, leaving large and fertile countries between them.

These slightly diverging lines of mountains yield gold, ores of silver and tin, and precious stones, as rubies and sapphires. Mountains in low latitudes have nothing of the severe character of those in less favoured climes. Magnificent forests reach their summits; trees yielding spices, dyes of brilliant tints, medicinal and odoriferous plants, clothe their declivities; and in the low grounds the fruits of India and China grow in perfection in a soil which yields three crops of grain in the year. The plains lying between these mountains are very extensive. The Birman empire alone, which occupies the upper and middle valleys of the Irawadi, is about half as large as France, and scarcely less fertile. Magnificent rivers intersect the alluvial plains, whose soil they have brought down from the table-land of Tibet, and still continue to deposit in great quantities in the deltas at their mouths, frequently forming bars which prevent the ascent of vessels of heavy burden, and the shores are devoid of ports to afford shelter from a tempestuous sea.

§ 5. **The Kingdom of Siam.**—Siam, which extends from the boundaries of British Burmah to Annam, has a population of 5,750,000, of which a million and a half are Chinese. They are less bigoted than the Hindus, but less civilised and industrious than the Chinese. Rice is the staple commodity, but sugar is now exported; and it is believed to be a country where the best sea island cotton may be produced, for a large group of islands lie 11 m. S. of the salubrious village of Arihirs, in the largest of which there is a fine harbour, into which the shipping from Bangkok retires in bad weather. With all these advantages, the territory in Siam that has been ceded to us is one of the most prosperous possessions in the British empire.

Since the French have taken possession of a portion of Kambodia and Cochin China, around and including the delta of the

[1] Address by Sir Roderick I. Murchison, President of the Royal Geographical Society.

Me Khong, they have explored the upper waters of this large river, making the unwelcome discovery that it is encumbered by rapids at a distance of only 300 m. above its mouth. An exploring party, under Captain de Lagrée, followed the river into the Chinese province of Yunnan, but the route was found full of difficulties, and little prospect exists of much trade arising in this direction.

§ 6. **The Plains of Hindustan.**—The plains of Hindustan extend 2000 m. along the southern slopes of the Himalayas, between the Brahmaputra and the Indus, and terminate on the S. in the Bay of Bengal, the table-land of the Deccan, and the Indian Ocean —a country embracing in its range every variety of climate, from tropical heat and moisture to the genial temperature of southern Europe.

The *Valley of the Ganges* is one of the richest regions on the globe, and contains a greater extent of vegetable mould, and of land under cultivation, than any other country in this continent, except, perhaps, the Chinese empire. In its upper part, Sirhind and Delhi, the seat of the ancient Mogul empire, still rich in splendid specimens of Indian art, are partly arid, although in the latter there is fertile soil. The country is beautiful where the Jumna and other streams unite to form the Ganges. These rivers are often hemmed in by rocks and high banks, which in a great measure prevent the periodical overflow of the waters; this, however, is compensated by the coolness and moisture of the climate. The land gradually improves towards the east, as it becomes more flat, till at last there is not a stone to be seen for hundreds of miles down to the Gulf of Bengal. Wheat and other European grain are produced in the upper part of this magnificent valley, while in the S. every variety of Indian fruit, rice, cotton, indigo, opium, and sugar, are the staple commodities. The ascent of the plain of the Ganges from the Bay of Bengal is so gradual that Saharampore, nearly at the foot of the Himalaya, is only 1100 ft. above the level of Calcutta: the consequence of which is that the Ganges and Brahmaputra, with their branches, in the rainy season between June and September, lay Bengal under water for hundreds of miles in every direction, like a great sea. When the water subsides, the plains are verdant with rice and other grain; but when harvest is over, and the heat is intense, the scene is changed—the country, divested of its beauty, becomes parched and dusty everywhere, except in the extensive jungles. It has been estimated that one third of the British territory in India is covered with these rank marshy tracts.[1]

---

[1] The estimate was made by Lord Cornwallis, and confirmed by Mr. Colebrooke.

Table-land of the Deccan.—The peninsula of Hindustan is occupied by the triangular shaped table-land of the Deccan, which is much lower than, and totally unconnected with, the table-land of Tibet. It has the primary ranges of the Ghats on the E. and W., and the Vindhya Mountains on the N., which slope by successive levels to the plains of Hindustan proper. A trace of the general equatorial direction of the Asiatic high land is still perceptible in the Vindhya Mountains, sometimes called the central chain of India, and in the Satpura range to the S., both being nearly parallel to the Himalaya.[1] The surface of the Deccan, between 1500 and 2000 ft. above the sea, is a combination of plains, ridges of rock, and insulated flat topped hills, which are numerous, especially in its N.E. parts. These solitary and almost inaccessible heights rise abruptly from the plains, with all but perpendicular sides, which can only be scaled by steps cut in the rock, or by very dangerous paths. Many are fortified, and were the strongholds of the natives, but they never have withstood the determined intrepidity of British soldiers.

The peninsula terminates with the table-land of Mysore, from 4000 to 5000 ft. above the sea, surrounded by the Nilgiri or Blue Mountains, which rise to an altitude of 8500 ft.

The base of this plateau, and a part of the Deccan, is granite, the rest one vast sheet of basalt. Though possessing the once famous and valuable diamond mines of Golconda, the true riches of the country consist in its vegetable mould, which in Mysore is 100 ft. thick, an inexhaustible source of fertility. The sea coasts on the two sides of the peninsula are essentially different; that of Malabar on the western side is rocky, but in many parts well cultivated, and its mountains covered with forests form a continuous wall of very simple structure, 510 m. long, and rather more than 3000 ft. high. On the coast of Coromandel the mountains are bare, lower, frequently interrupted, and the wide maritime plains are generally parched.

The Island of Ceylon, nearly equal in extent to Ireland, is almost joined to the southern extremity of the peninsula by sandbanks and small islands, between which the water is only 6 ft. deep at low water spring tides. The Sanscrit name of the 'Resplendent' may convey some idea of this island, rich in soil, and fertile, adorned by lofty mountains, numerous streams, and primeval forests; in addition to which it is rich in precious stones, and has fisheries of the pearl oyster on its coast.

§ 7. **The Panjab.**—The Asiatic low lands are continued westward from the Indian peninsula by the Panjab and the great

---

1 Johnston's 'Physical Atlas.'

Indian desert. 'The Panjab, or country of the five rivers,' lies at the base of the western Himalayas. Its most northern part consists of fertile terraces highly cultivated, and valleys at the foot of the mountains. It is very productive in the plain within the limits of the periodical inundations of the rivers, and where it is watered by canals; in other parts it is pastoral. The kingdom of Lahore occupies the chief part of the Panjab, and the city of that name near the Ravi, once the rival of Delhi, lies on the high road from Persia to India, and was made the capital of the kingdom by the founder of the Sikh dynasty, Runjeet Sing. The lower valley of the Indus throughout partakes of the character of the Panjab; it is fertile only where it is within reach of water: much of it consists of a delta, which is occupied by rice grounds; the rest is pasture, or sterile salt marshes.

§ 8. **The Great Indian Desert.**—South of the Panjab, and between the plains of Hindustan and the left bank of the Indus, lies the great Indian desert, which is about 400 m. broad, and becomes more and more arid as it approaches the river. It consists of a hard clay, covered with shifting sand, driven into high mounds by the wind, with some parts that are verdant after the rains. In the province of Cutch, S. of the desert, a space of 9000 sq. m., known as the 'Runn of Cutch,' is alternately a sandy salt plain, level as a bowling green, and an inland sea. In April the waves of the sea are driven over it by the prevailing winds, leaving only a few grassy eminences, the resort of the wild ass. The Desert of Mekran, an equally barren tract, extends along the Gulf of Oman from the mouths of the Indus to the Persian Gulf: in some places, however, it produces the Indian palm and the aromatic shrubs of Arabia Felix. It was the line followed by Alexander the Great returning with his army from India.

The scathed shores of the Arabian Gulf, where not a blade of grass freshens the arid sands, and the uncultivated valleys of the Euphrates and Tigris, separate Asia from Arabia and Northern Africa, the most desert regions in the old world.

§ 9. **The Arabian Peninsula.**—The peninsula of Arabia, divided into two parts by the Tropic of Cancer, is about four times the size of France. There are no rivers, and few streams or springs nourish the thirsty land, whose barren sands are scorched by a fierce sun. The central part is a table-land of moderate height, which, however, is said to have an elevation of 8000 ft. in the southern province of Hadramaut. To the S. of the tropic it is an almost interminable ocean of drifting sand, wafted in clouds by the gale, and dreaded even by the wandering Bedouin. At wide intervals, long narrow depressions cheer the eye with brushwood and verdure. More to the N., mountains and hills cross the peninsula

from S.E. to N.W., enclosing cultivated and fine pastoral valleys adorned by groves of the date palm and aromatic shrubs. Mr. Gifford Palgrave, in the years 1862–63, crossed Arabia from a point two days' journey to the N. of Akaba to El Khatif on the shores of the Persian Gulf. In this journey, a waterless desert was first crossed, which reaches to the frontiers of the kingdom of Jebel Shomer. This independent principality lies between 26° 30′ and 32° N.; and between 33° 40′ and 44° E. Two thirds of this area is desert; but there are here and there fertile spots, such as Jauf, where lovely villages nestle under palm trees, and such as the approaches to Haîl, the capital, lying among fertile valleys, many of which run from N.E. to S.W. The kingdom of the Wahabees, whose sovereign is known as the Sultan of Nejd, lies S.E. of the kingdom of Jebel Shomer, and extends over 10° of latitude and 7° of longitude, being bounded on the W. by one of the pilgrim routes to Medina, and on the E. by the Persian Gulf. The capital is Riad, and besides this there are many fortified towns standing in the midst of widely extended gardens and plantations. The broad and fertile plains of Kasim intervene between Jebel Shomer and the Nejd territory, the latter of which is elevated, and in it is found the plateau of Jebel Toweyk, having an elevation of 2000 ft. This plateau has much pasture land, on which countless herds of camels and sheep graze. It is intersected by a network of valleys full of life and cultivation. Eastward of Riad fine plains were found; but before reaching the fertile coast strip, the 'Dahna' or Red Desert, an offshoot of the southern desert, had to be crossed. El Khatif on the Persian Gulf is surrounded by a network of rivers, and is buried in an interminable succession of gardens. The table-land descends in terraces or parallel ranges of mountains and hills to a flat sandy coast from 30 to 100 m. wide, which surrounds the greater part of the peninsula, from the mouths of the Euphrates to the Isthmus of Suez. The hills come close to the beach in the province of Oman, which is traversed by chains, and broken into piles of arid mountains not more than 3500 ft. high, with the exception of the Jebel Akhdar,[1] which is 6000 ft. above the sea, and is cleft by temporary streams and fertile valleys. Here the ground is cultivated and covered with verdure, and still farther S. there is a line of oases fed by subterraneous springs, where the fruits common to Persia, India, and Arabia are produced.

The southern coast is scarcely known, except towards the provinces of Hadramaut and Yemen, or Arabia Felix, where ranges of mountains, some above 5000 ft. high, line the coast, and in

1 *Jebel Akhdar* = 'Green Mountain.'

many places project into the ocean, sometimes forming excellent harbours, as that of Aden, which is protected by projecting rocks. In the intervals there are towns and villages, cotton plantations, date groves, and cultivated ground.

On the northern side of these granite ranges, where the table-land is 8000 ft. above the sea, and along the edge of the Desert of El Aklaj in Hadramaut, there is a tract of sand so loose and so very fine, that a plummet was sunk in it by Baron Wrede to the depth of 360 ft. without reaching the bottom. There is a tradition in the country that the Sabæan army of King Suffi perished in attempting to cross this desert. Arabia Felix, which merits its name, is the only part of that country with permanent streams, though they are small. Here also the mountains and fertile regions run far inland, producing grain, pasture, coffee, odoriferous plants, and gums. High cliffs line the shores of the Indian Ocean and the Strait of Bab-el-mandeb (= 'the Gate of Tears'). The fertile country is continued a considerable way along the coast of the Red Sea; but the character of barrenness is resumed by degrees, till at length the hills and intervening terraces, on which Mecca and Medina, the holy cities of the Mohammedans, stand, are sterile wastes wherever springs do not water them. The blast of the desert, loaded with burning sand, sweeps over these parched regions. Mountains skirt the table-land to the N.; and the peninsula, between the Gulfs of Akaba and Suez on the Red Sea, is filled by the mountain group of Sinai and Horeb. Jebel Houra, Mount Horeb, on which Moses received the Ten Commandments, is 8593 ft. high, surrounded by still higher peaks, which are covered with snow in winter. The group of Sinai abounds in springs and verdure. At its northern extremity lies the Desert of El Tîh, 70 m. long and 30 broad, in which the Israelites wandered 40 years. It is covered with long ranges of high rocks, of most repulsive aspect, rent into deep clefts only a few feet wide, hemmed in by walls of rock sometimes 1000 ft. high, like the deserted streets of a Cyclopean town. The journey from Sinai to Akaba, by the Wady el Ain, or Valley of the Spring, is magnificent, and the site of Petra itself is a tremendous confusion of black and brown mountains. It is a considerable basin closed in by rocks, with chasms and defiles in the precipices. The main street is 2 m. long, and not more than from 10 to 30 ft. wide, enclosed between perpendicular rocks from 100 to 700 ft. high, which so nearly meet as to leave only a strip of sky. A stream runs through the street which must once have been a considerable torrent, and the precipitous rocks are excavated into thousands of caverns once inhabited—into conduits, cisterns, flights of steps, theatres, temples, and sepulchres, forming altogether one of the most wonderful remains of antiquity. The

whole of Arabia Petrea, the Edom of sacred writers, presents a scene of appalling desolation, completely fulfilling the denunciation of prophecy.

§ 10. **Syria.**—A sandy desert, crossed by low limestone ridges, separates the table-land of Arabia from the habitable part of Syria, which the mountains of Lebanon divide into two narrow plains. These mountains may also be considered offsets from the Taurus chain; at least, they are connected with it by the range of Alna Dagh, the ancient Amanus, impassable except by two defiles, celebrated in history as the Amanic and Syrian Gates. The group of Lebanon begins with the Jebel Akra (5872 ft.) (Mount Cassius), which rises abruptly from the sea in a single peak near the mouth of the Orontes. From thence the chain runs S. at a distance of about 20 m. from the shores of the Mediterranean, in a continuous line of peaks to the sources of the Jordan, where it splits into two nearly parallel branches, enclosing the upper valley of the River Litany, the ancient Leontes, and the wide and fertile plain of Buka, the ancient Cœle-Syria, in which are the ruins of Baalbek.

The *Lebanon branch*, the western range, contains the high peak of Dhor el Kodib (10,161 ft.) and Jebel Sannum (8162 ft.). South of the latter of these mountains the range sinks down, expanding in breadth as it diminishes in height. It forms by its spurs and their continuations the hill country of Galilee, that of Samaria, and the S. country of Judea, which gradually fades away into the Desert of Paran, the modern El Tih. Plains and valleys are enclosed among those hills, and border the Mediterranean coast. The *Anti-Libanus*, which commences N.E. of Baalbek, attains its greatest height in Jebel es Sheik (9053 ft.) or Mount Hermon, near the centre of the chain, from whence it runs along the left bank of the Jordan, forming the trans-Jordanic range, which everywhere bounds the eastern horizon to the traveller in western Palestine, the long straight line of the mountains of Ajlun, Gilead, and Moab.

To the E. and S.E. of Hermon extends a vast rugged region comparatively unmarked by any high peaks, but seamed and furrowed by endless hidden ravines, cracks in the molten sea of lava which has once been poured over the whole country, and which has cooled down a very sea of black rock. This district, the Argob of the Old Testament, the Trachonitis of the New, is now called the Lejah; and in its cracks and fissures still maintains a considerable population.

The tops of all the mountains, from Scanderoon to Jerusalem, are covered with snow in winter; but it is permanent on Lebanon only. The precipices are terrific, the springs abundant, and the

spurs of the mountains are studded with villages and convents; there are forests in the higher grounds, and lower down vineyards and gardens. Many offsets from the Libanus end in precipices on the coast between Tripoli and Beyrout, among which the scenery is very beautiful.

The *valleys and plains of Syria* are rich in their vegetable soil, particularly the plain of Damascus, which is brilliantly verdant, though surrounded by deserts, the barren uniformity of which is relieved on the E. by the ruined temples of Palmyra (Tadmor). The Syrian wilderness, however, is not everywhere absolutely barren. In the spring time it is covered with a thin but vivid verdure, mixed with aromatic herbs of very short duration. When these are burnt up, the unbounded plains resume their wonted dreariness. The country, high and low, becomes more barren as we approach the Holy Land, yet even here some of the mountains—as Carmel, Bashan, and Tabor—are wooded, and many of the valleys are fertile, especially the valley of the Jordan, which has the appearance of pleasure grounds with groves of trees and aromatic plants. The sea coast plains are often of 'surpassing richness, yielding in profusion the crops of southern Europe, corn, millet, and abundance of fruits, with rich gardens and orchards around the cities.' The greater part of Syria is now a desert compared with what it formerly was. Mussulman rule has blighted this fair region—the Land of Promise, once flowing with milk and honey.

The *valley of the Jordan*, called El Ghor, affords the most remarkable instance known of the depression of a considerable tract of land below the general level of the ocean. El Ghor is not a valley merely, but a sunken chink, ploughed deep down into the bowels of the earth. From the source of the river in the Anti-Lebanon the valley steadily deepens. The first pause is in the wide basin of Lake Merom, the modern Huleh, from which the valley rapidly descends to the Sea of Galilee. Leaving this lake, the river runs in a tortuous course of 200 m. long, through the valley to the great depression of the Dead Sea, 1292 ft. below the level of the Mediterranean, the deepest depression on the earth's surface. The lower terraces of the valley which constitute the edge of the Ghor, or 'Plain of the Jordan' of the Jews, form a narrow trench, rarely more than 2 m. wide, while the upper terraces reach back for several miles to the enclosing hills. Southward of the Dead Sea, this deep trench continues in the Arabah, but gradually rises, until a little south of Petra the watershed of the Dead Sea and the Red Sea is found at a height of 787 ft. above the sea level, to which the valley of Akaba thence descends.

The natural products of the Jordan valley are unique. It is a tropical oasis, sunk in the temperate zone, and overhung by an Alpine Hermon. Acres of papyrus are found in the marshes of Lake Merom; the plain of Gennesaret, on the W. shore of the Sea of Galilee, also produces papyrus, and the jujube (a tropical tree). Palms and oleanders wave in the valley S. of Galilee, and round the Dead Sea; in five oases are found, nourished by copious springs, many of the products of the torrid zone. Indigo and henna flourish, and melons ripen in a winter during which the thermometer ranges between 60° and 80° Fahr. The birds and insects also are either peculiar to the district, or are such as are found in Nubia, Abyssinia, India, and Equatorial Africa. The Jordan valley is an actual geological line, the formations differing on each side. The Dead Sea has been shown by M. Lartet to have had no connection with the Red Sea since the continent assumed its present form. Many hot springs and sulphur springs are found in the basin of the Dead Sea; but Jebel Usdum, a mass of rock salt, 7 m. long, a mile and a half wide, and several hundred feet high, is the most interesting phenomenon about the lake. M. Lartet considers that the Dead Sea has never been anything but a reservoir for the water brought in by the various streams, deriving its saltness partly from the salt rocks near it and partly as a result of incessant evaporation.[1]

There is evidence that the country round the northern end of the Red Sea has been raised above its former level within the last 3000 years. Caverns are found in the cliffs on the Red Sea, and in those more inland on the Arabian coast; and the whole desert from Suez to Cairo is covered with abundance of shells, similar to those now living in the Red Sea, which was probably joined to the Mediterranean at a very recent period.

It appears from the surveys which were executed with a view to unite the two seas by a canal, that they are on the same level; that for 13½ m., from high water mark at Suez to the Bitter Lakes, the land is nearly level, rising from 3 to 12 ft. only above the highest tide. Here a depression of 16 ft. begins, which extends for 27 m. The surface of the Bitter Lakes, which appear to be fragments of the Red Sea or Mediterranean, lowered by evaporation, is 54 ft. below the level of the latter. From thence to the Mediterranean the ground is low and marshy, with numerous lagoons of salt water. The shortest distance from the Red Sea to the Mediterranean is 75 m. The canal which, through the energy of M. de Lesseps, has been made from sea to sea was

---

[1] Canon Tristram's chapters on the Physical Geography of Palestine in his 'Natural History of the Bible.'

opened in 1869. It cuts through the low sandy isthmus to the E. of the delta of the Nile, and passes from Lake Menzaleh, the most easterly of the lagoons formed round the delta of the Nile, to the head of the Gulf of Suez. It passes through the shallow lake Menzaleh, the small lakes El Ballah and Timsah, and a fourth formed in the basin of the Bitter Lakes, by water let into it from the Mediterranean, which has raised their level. The length of the canal is about 90 m., and its depth 26 ft.; it has no locks. The general width is 246 ft. at the base of the banks, and 72 ft. at the bottom of the canal. A new town, called Port Said, has been established at the northern end of the canal, and another Ismailia, on Lake Timsah. The Natron lakes on the Libyan Desert, W. from the delta of the Nile, are probably also fragments of an inland sea.[1]

CHAPTER VIII.

AFRICA.

§ 1. **Configuration of the African Continent.**—The continent of Africa is 5050 m. long from Cape Agulhas, E. of the Cape of Good Hope, to Cape Bianco, near Bizerta, its northern extremity, and 4600 broad, between Cape Guardafui, on the Indian Ocean, and Cape Verd, on the Atlantic; but from the irregularity of its figure it has an estimated area of 11,244,948 sq. m. It is divided into two, nearly equal, parts by the equator, consequently the greater portion of it lies under a tropical sun. The high and low lands of this division of the old continent are so distinctly separated that, with the exception of the mountainous territory of the Atlas and the small table-land of Barca, it may be said to consist of two parts only, a high country and a low.

§ 2. **South African Table-land.**—An extensive, though not very elevated, table-land occupies all S. Africa, and stretches 6 or 7 degrees N. of the equator. On the N.W. it terminates in the high land of Senegambia, and on the N.E. in that of Abyssinia, both of which project farther to the N. than the central edge of the plateau, which has not yet been explored. On the E. and W. the table-land is bounded either by mountain chains or high ridges of various kinds and elevations, which divide it from the narrow

---

[1] See the works of Dr. Buist, Mr. Glyn, and the Survey published by M. de Lesseps. Miss Fanny Corbaux was one of the first who drew attention to this subject.

coast plains and the deltas of rivers which terminate in the Indian and Atlantic Oceans; and on the S. the table-land shelves down to the sea by a series of terraces called 'karroos.'

§ 3. **The Cape of Good Hope and the E. Coast.**—In its southern extremity at the Cape of Good Hope the African continent is about 700 m. broad, and ends in three narrow parallel ridges of mountains, the northernmost of which is the highest, and abuts on the table-land. All are cleft by precipitous deep ravines, through which winter torrents flow to the ocean. The longitudinal valleys, or karroos, that separate them, are tiers, or steps, by which the plateau dips to the maritime plains. The descent is rapid, as both these plains and the mountain ranges are very narrow. On the western side they form a high group, and end in steep promontories on the coast, where Table Mountain, 3550 ft., at Cape Town, forms a conspicuous landmark for mariners.

Granite rocks, which are the base of this part of southern Africa, rise to a considerable height in many places, and are generally surmounted by vast horizontal beds of sandstone, which give that character of flatness peculiar to the summits of many of the Cape mountains.

The karroos are arid deserts in the dry season, but soon after the setting in of the rains they are covered with verdure and a splendid flora. The maritime plains partake of the same temporary aridity, though a large portion is rich in cereal productions, vineyards, fruits, and pasture.

The most inland of the ranges parallel to the Indian Ocean is 10,000 ft. high, and it rises about the 27th meridian, in a truly Alpine and continuous chain—the Quatlamba Mountains, which sink into a broad ridge not more than 4000 ft. above the level of the sea before crossing the Zambesi River at the beginning of its delta, about 300 m. from the ocean. The surface of the ridge is a fine undulating country, covered with short grass like a lawn, and yielding excellent wheat and other cereals, with various roots in great abundance. From the head of the delta the ridge which borders the table-land divides into several branches. One, known as the Lupata chain, runs at the distance of 160 m. inland along the coast of Sofala; others bend W., while the central and principal chain runs N., encircling Lake Nyassa at a considerable distance from the coast. It is of moderate altitude in the country of Unyamwesi, but rises to a great height between 3° and 4° S. lat., where Kilima-Njaro (18,715 ft.) rises to the zone of eternal snow, and other peaks seem to connect the range with the high lands of Abyssinia.

At Natal the coast land slopes upward from the sea to the

summit of the range, here called the Drakenberg, and the climate and vegetation of the valleys, exposed to the warm and moist airs of the Indian Ocean, are subtropical. The Zambesi and other streams from the table-land refresh the plains on the Mozambique Channel. Opposite Zanzibar, though some parts are marshy and covered with mangroves, groves of palm trees adorn the plains, which yield prodigious quantities of grain, and noble forests cover the mountains; but from 4° N. latitude to Cape Guardafuï is a continued desert, the hot and dry region inhabited by the jealous and ferocious Somali. There is also a barren tract at the southern end of the Lupata chain, and along the southern tributaries of the Zambesi, where gold is found in masses and grains on the surface and in the watercourses, which tempted the Portuguese to form settlements on these unwholesome coasts. Here were situated Manica, and the country of Monomotapa, depicted on old maps, and the district, together with the seaport Sofala, is suggested by some writers to be the Ophir of Scripture.

The *Island of Madagascar*, with its magnificent range of mountains, encircled by a belt of primeval forests, is parallel to the African coast, and only separated from it by the Mozambique Channel, 250 m. broad; its organic productions as a whole differ very greatly from those of Africa, showing that there has been no connexion between the two lands since they were stocked by their present forms of life.

§ 4. **The West Coast of South Africa.**—The contrast between the E. and W. coasts of S. Africa is very striking. The bold escarped mountains round the Cape of Good Hope, and its rocky coast, which extends a short way along the Atlantic to the N., are succeeded by ranges of sandstone of small elevation, which separate the internal sandy desert from the sandy shore which, with the exception of Walfisch Bay, is equally parched. The terraced slope of the Atlantic coast for 900 m. between the Orange River and Cape Negro has not a drop of fresh water.

At *Cape Negro* terraces separated by long level tracts begin and make a semicircular bend into the interior, leaving plains along the coast 140 m. broad, from whence the highest terrace appears like a chain of mountains, because it dips for 2000 ft. towards them. It has a broad flat top, spreading into fine grassy plains, on which are found Cape heaths, rhododendrons, and other Alpine plants, quite different from the tropical vegetation on the maritime coast on one side, or on the table-land on the other. The high terraces are continued to the country of Colbongos, the most elevated land on the coast, where a magnificent group of mountains, covered to their tops with large timber, lie not far inland and N. of these.

King William's Mountains form the eastern border of this side of the table-land.

The *maritime plains* on the Atlantic along this long line of high country have for the most part a tropical vegetation. In Benguela the plains are healthy and cultivated; farther N. there are monotonous grass savannahs, and forests of gigantic trees. The ground, in many places saturated with water, bears a tangled crop of mangroves and tall reeds which even cover the shoals along the coast; hot pestilential vapours hang over them, never dissipated by a breeze. Such are the low lands of the Fernan Vaz River and the Gaboon, and farther N. the plains of Biafra and Benin, and the delta of the Niger.

The Angel of Death, brooding over these regions in noisome exhalations, guards the interior of that country from the aggressions of the European, and has hitherto baffled his attempts to form settlements on the banks of this magnificent river.

Many portions of N. Guinea are so fertile that they might vie with the valley of the Nile in cereal riches, besides various other productions; and, though the heat is great, the climate is not very unhealthy.

Such are the mountain chains and maritime plains that surround the table-land of South Africa on three sides.

§ 5. **Table-land North of the Cape; Dr. Livingstone's Discoveries.**—In the beginning of the present century the table-land N. of the Cape of Good Hope was almost an unknown region. Mr. Somerville and Mr. Trotter were the first white men whom the inhabitants of Litakoo had seen. Of an expedition that followed their track a few years afterwards no one returned. Since that time it has been frequently explored both by the missionaries and other travellers, and now the central portion, as far as the Victoria Falls of the Zambesi, is tolerably well known.

Immediately N. of the Cape mountains the table-land is 600 ft. above the level of the sea, and, for a comparatively small distance, it is cultivated and pastoral, and in all probability it is equally so at the foot of the Quatlamba chain; for there are forests and rich pasture lands in the Bushmen's country, at least for part of the year. With these exceptions the Kalahari Desert spreads over the table-land to the 20th degree of S. latitude. The Gariep, or Orange River, with its tributaries, which flow across the desert, may be more aptly said to drain than to irrigate this arid country. Many of the tributaries are only the channels through which torrents from the periodical rains are carried to the main stream, and are destitute of water during many months in the year. 'The Dry River,' the name of one of these, is no misnomer in that country. However, moisture is not wanting, for the margin of the

streams is usually adorned with mimosas, and the sandy deserts in some places have furnished treasures to the botanist after the rains; but in general the camel's thorn and other products of the African desert are the only vegetation, where there is any vegetation at all. On the W. it is bounded by the pastoral and even agricultural countries of the Great Namaqua and Damaras, but these are penetrated in many places by the desert, even to the sandy shores.

Nothing was known of the interior of the table-land N. of the Kalahari Desert, till, in 1802, intelligent native merchants crossed from Loanda on the Atlantic to Zanzibar on the Mozambique coast, and from their account Europeans first had an idea of the nature of the country, its productions, and the state of its inhabitants; but it is to the missionaries that we owe our real knowledge of the interior of South Africa. Among these Dr. Livingstone is preeminent. Of high scientific acquirements and unconquerable zeal in the great cause, he traversed the table-land from sea to sea, performing in all a journey of 11,000 m., in order to establish missions for the conversion and instruction of the natives. Although that was his principal object, yet during the journey, amidst innumerable difficulties and thirty two attacks of fever, he made astronomical observations to ascertain the latitude and longitude of the most remarkable places he visited. Dr. Livingstone set out from Kolobeng, the advanced post of the missionaries N. from the Cape of Good Hope, and after a month's journey over 300 m. of desert, in great want of water, he came to the banks of the Zouga, a noble and exquisitely beautiful river, richly fringed with fruit bearing and other trees, and communicating with Lake Ngami, which he first visited in 1849, and which is from 50 to 70 m. long, and 2930 ft. above the level of the sea. The Zouga is the most southerly of that magnificent series of rivers discovered by Dr. Livingstone in the very centre of South Africa, which extends from the 20th parallel of S. latitude to within 10 degrees of the equator, and in longitude throughout the whole breadth of the table-land.

The country N. of Lake Ngami is a dead flat for hundreds of miles, interlaced by a perfect labyrinth of rivers with their countless tributaries and numerous entering and reentering branches, on account of which it is called Linoka-noka, or 'Rivers upon Rivers.' The waters of this network of lakes and rivers, deflected in various directions by slight elevations, escape to the eastern and western oceans by passing through deep rents in the flanking ridges on each side of the plateau. In many places the meadow lands are the pasture grounds of the natives, covered with thousands of cattle, but in the forests both horses and cattle fall victims to the tsetse, a poisonous fly which abounds there. Large tracts of

this country are inundated during the periodical rains, and, when the water retires, the rank vegetation and wide spreading marshes under a tropical sun send forth exhalations nearly as fatal to man as the tsetse is to cattle; indeed, one place is called The Fever Ponds.

The Zambesi is the main watercourse of the magnificent river system into which all the lesser systems and streams flow, many of which are great deep rivers. The natives are quite aware of its importance, since its various names of Luameji, Leeambye, and Zambesi, simply mean 'The River.' It makes various windings in its course from the W., especially an almost semicircular bend to the S., at the extremity of which, in 17° 57′ S. lat. and 26° 6′ E. long., it forms a magnificent cataract, broader and higher than Niagara, descending into a very remarkable zigzag cleft in the rocks 350 ft. deep, to which the name 'Victoria Falls' has been given. Then it flows N. in rapids till it is joined by its tributary the Kafue, when it turns E. and flows generally in that direction to the Mozambique Channel, forming a delta 300 m. long. In some places the river is a mile broad, with islands covered with the richest vegetation of large trees, among which the date palm and the lofty palmyra are the most beautiful.

The productions of this country are most valuable. The Roman Catholic missionaries introduced the pine apple, which now grows for miles along the roads in Angola; and, what is of more importance, the finest Mocha coffee, which grows wild in the greatest abundance. Dr. Livingstone found the vine loaded with bunches of dark purple grapes, the indigo plant in great abundance, the sugar cane, papyrus, a strong kind of flax, buáze, senna, and, in the woods where fever prevails, a kind of cinchona, which the natives use as a remedy against that malady. They cultivate wheat, manioc, yams, millet, rice, bananas, and vast quantities of Caffre corn. The sugar cane has been cultivated by them from time immemorial, though they have never discovered how to make sugar from it. Elephants' tusks and beeswax are articles of commerce the pioneer to the hives being the honey bird, a species of cuckoo The enormous quantity of wild animals shows that pasture land in this upper region of the Zambesi must be very extensive. Dr. Livingstone fell in with troops of elephants exceeding anything hitherto described, and so tame that he was obliged to halloo to them to get out of the way; besides buffaloes, giraffes, zebras, antelopes, and wild hogs in great numbers.

The mineral riches are very considerable. The town of Tete, on the Zambesi, stands in an extensive coal field, part of which is surrounded by a gold producing district; and iron, of a quality equal to that of Sweden, is used by the natives for their weapons.

In 1859 Dr. Livingstone discovered the great freshwater lake Nyassa, which stretches nearly N. and S. 250 m. with a width varying from 20 to 60 m., and an area of 9000 sq. m. It is not a shallow sheet of water like Lake Ngami, but is of great depth, with the water as blue as that of the ocean; no bottom was found in some places with a line of 40 fathoms. A range of mountains borders the lake on each side, from which descend numerous perennial streams; the prevailing winds are from the S.E., and they blow with such force, in the height of the dry season, when not a cloud obscures the sky, that an ordinary sailing boat runs hourly risk of being capsized. The lake lies at an altitude of 1522 ft. above the sea level, and at the S. end the surplus waters flow off by the River Shire towards the Zambesi, the river forming a series of cataracts and rapids in its descent towards the low country. To the S.E. of this magnificent sheet of water, and separated from it by an isthmus 30 m. wide, lies Lake Shirwa, a much smaller area, enclosed by mountains on the border of the plateau at an elevation of 2000 ft. above the sea: its brackish waters have no outlet.

§ 6. **Tropical Africa; Explorations of Burton, Speke, Baker, Livingstone.**—While Dr. Livingstone was making these remarkable discoveries Captains Burton and Speke returned from a journey which they made from Zanzibar into the interior of tropical Africa more to the N. They ascended the River Pangany for 120 m. through an unhealthy but rich and rather well cultivated plain, and crossed the coast chain of mountains, about 60 m. broad. The interior, at first poor, soon became a luxuriant country, in which tobacco, cotton, and various useful plants are cultivated by a peaceful race of negroes who possess abundance of cows and goats, and know how to manufacture both iron and cotton. On proceeding into the interior the travellers discovered the Lake Tanganyika, which lies between the parallels of 3° 10′ and 7° 50′ S. lat., its centre being in about 30° E. long. It abounds in good fish, and, as the tsetse fly does not infest this part of Africa, its banks are browsed by the red oxen that are common throughout the country, and occasionally have stupendous horns. At a distance of 200 m. of very lofty mountainous country N.W. from Lake Tanganyika, Captain Speke came to a great freshwater lake called the Victoria Nyanza, 3808 ft. above the level of the sea, which he believed to be the ultimate source of the Nile, and which he afterwards revisited in company with Captain Grant. On this latter memorable expedition, the two travellers traversed the region of Equatorial Africa from Zanzibar to the upper waters of the Nile, emerging on the Mediterranean in the month of June 1863. They skirted the W. shores of the lake, but seldom sighted its waters, and then, after following the stream which drained it on the N. for some

portion of its course, struck across for the White Nile. They were informed by the natives that this stream entered, not far to the W., a second great lake before it reemerged as the Nile. Regretting that he was unable to visit this second lake, the Luta Nzige, Captain Speke, on his arrival at Gondokoro, recommended Mr. (now Sir Samuel) Baker, who had come up the Nile bringing succour to the expedition, to endeavour to reach it. The advice was taken, and in 1864 the result, as is now well known, was the discovery of the Albert Nyanza, a still grander sheet of water than the Victoria, lying in a deep trough amid lofty mountains and glorious Alpine scenery. The Albert Nyanza lies at an altitude of about 2720 ft. above the sea level, or above 1000 ft. lower than the Victoria Lake, the slope of the country being from S.E. to N.W.

In 1866 Livingstone commenced the last and most important of his journeys. Entering Eastern Africa, near the mouth of the Rovuma, he penetrated to the E. shore of Lake Nyassa. Having rounded the S. end of the lake he turned N., and, traversing the Lobisa highlands, he proceeded to the Cazembe, and to Ujiji on Lake Tanganyika, discovering on the way the great Lake Bangweolo, and that grand river, the Lualaba. Communications from him suddenly ceasing, he was sought, found, and relieved, by Mr. Stanley, who left him again in March 1872. In the following August Livingstone resumed his explorations, but died in May 1873, near the shores of Lake Bangweolo. The great traveller's principal object in this expedition had been 'to define the true watershed of inner Africa.'

After the death of Livingstone, Lieut. Cameron, who had been sent out at the head of the Livingstone Relief Expedition, explored the great drainage system S.W. of Livingstone's lakes, and had determined that those waters were probably connected with the Congo, and not with the Nile. Continuing his journey westward, he reached Benguela, on the coast, in September 1875, having traversed nearly 3000 m., of which about 1200 were over entirely new ground.

§ 7. **Abyssinia; Physical Characteristics; Geological Structure.**—The vast Alpine promontory of Abyssinia or Ethiopia,[1] 700 m. wide, projects from the table-land for 300 m. into the low lands of North Africa. It dips to a low swampy region on the N., to the plains of Senaar and Kordofan on the W., and on the E.

[1] The name of Ethiopia is still used by the Abyssinians, as stated by M. A. d'Abbadie, who resided many years among them, as including Abyssinia proper, the Bija country as far as Sawakin, the Afar (Aidal of our maps), the Somaly, Gurage, and Galla countries. The word Abyssinia, according to the same traveller, is better employed in the Arab sense for those populations, chiefly Christian, which have lost all idea of tribe.

sinks abruptly to the coast at a short distance from the shores of the Red Sea. It is there from 8000 to 9000 ft. high on the plateau of Tigre, but declines towards the west, so that in the 15th parallel of N. lat. the E. slope of the table-land towards the Red Sea is nearly 20 times greater than the counter slope towards the Nile; the edge of the latter, however, is from 3000 to 4000 ft. above the plains.[1] The table-land of Abyssinia is a succession of plains, diversified by higher insulated mountain masses, which in the S. attain an altitude of from 12,000 to 15,000 ft.[2] These plains are intersected by the extremely deep ravines in which flow the numerous streams that form the tributaries of the Nile on the one hand, and the Hawash and its affluents, which flow towards the Indian Ocean, to be lost in a swamp, or in the salt plains, on the other. The edge of the table-land on the W. is steep; the streams run to the low lands through valleys from 3000 to 4000 ft. deep. These gorges have often wild and extremely picturesque scenery. They contain in their depths a tropical vegetation, while towards their upper portions, the flora of Italy and of England find representatives. A traveller in ascending them might imagine that he is crossing a mountain range, whereas, on coming to the top, he finds himself on a high plain. This elevated country has lakes, swamps, verdant meadows, and cultivated land, producing various kinds of grain, and on the western mountains coffee grows wild. The plain of Dembea, the granary of the country, enjoys perpetual spring. M. A. d'Abbadie and Dr. Beke travelled to within 8° of the equator, and, by their account, the country S. of Abyssinia appears to be similar to that of Shoa and Gojam—extensive undulating plains, with occasional mountain masses, and traversed by numerous streams; wide tracts must be 7000 or 8000 ft. high, as they only produce barley: the country towards Kaffa and the sources of the Gojeb is still higher, and in some parts desert; but the caravan road between Wallega and Kaffa passes through a vast forest impervious to the rays of the sun, which, according to the accounts of the merchants, is not seen for four or five days successively; and W. of the Did-ësa there are immense grassy plains, the elephant hunting grounds of the Galla tribes.

The expedition sent from England, in 1868, for the relief of the British prisoners detained by King Theodore was accompanied by scientific men who carefully examined the geography of the country through which the force passed. The Wadela and

---

[1] Estimated from N.E. to S.W., the proportion of the two slopes of the Abyssinian table-land is as 12·6 to 1.

[2] The highest inhabited village visited by M. d'Abbadie was that of Arquiaze, in the province of Simën, 12,450 ft. above the sea.

Dalanta plateaux, which were crossed on the road to Magdala, have an elevation of over 9000 ft.; and it is evident, says Mr. Clements Markham, that they were once a single mass of columnar basalt. The River Jitta has in the course of ages cut a deep ravine of 3500 ft., which has almost perpendicular sides, between these plateaux. The Beshilo ravine, still deeper than that of the Jitta, bounds the Dalanta plateau on the S.; and the Magdala system, or knot of mountains, lies with others still farther to the S. The country here consists of mountain masses, many with perpendicular sides only broken by terraces, and with flat summits on which forts have been constructed. These mountains are separated by deep ravines and gorges. Magdala itself is a mass of columnar basalt, with scarped perpendicular sides, and with a waterless plateau on the top, which is about 2 m. long by half a mile across; it is 9050 ft. above the level of the sea. The lofty ridges and deep ravines of the country round Magdala are very grand, and overtopping them all rises the straight basaltic wall of Dalanta.

The geological structure of Abyssinia is somewhat similar to that of the Cape of Good Hope, the base being granite and the superstructure sandstone, occasionally limestone, schist, and breccia. The granite comes to the surface in the lower parts of Abyssinia; but sandstone predominates in the upper, and assumes a tabular form, often lying on the tops of the mountains in enormous flat masses, only accessible by steps cut in the rocks or by ladders: such insulated spots are used as state prisons. Large tracts of ancient volcanic rocks occur, especially in Shoa. Trap rocks also abound in Simën. Many of the hill forts in Abyssinia are basaltic.

§ 8. **Senegambia.**—The appendage to the western extremity of the table-land also projects far into the low lands, and is the watershed whence the streams flow on one side to the plains of Soudan, where they join the Joliba or Niger; and from the other to the Gambia, Senegal, and to other rivers which run into the Atlantic over a plain, rich, cultivated, but unhealthy from the rankness of the vegetation.

§ 9. **Lowlands and Deserts.**—The moisture that descends from the northern edge of the table-land of South Africa, under the fiery radiance of a tropical sun, fertilises a tract of country stretching from sea to sea across the continent, the commencement of the African low lands. A great part of this region, which contains many kingdoms and commercial cities, is a very productive country. The abundance of water, the industry of the natives in irrigating the ground, the periodical rains, and the tropical heat, leave the soil no repose. Agriculture is in a rude state, but

nature is so bountiful that rice, millet, and other grains are raised in sufficient quantity to supply the wants of a numerous population. Gold is found in the river courses, and elephants abound in the forests; but slaves form the staple of the commerce of these States.

In the very centre of this fine country lies Lake Tchad, almost like a sea, and receiving many large rivers, especially the Shari and Mayo; the latter is mentioned by Dr. Barth as only to be compared with the Nile at highest flood. The celebrated port of Kábara, near which the city of Timbuctu is situated, is several miles from the river, and only accessible during five months in the year, when the rains are heavy. It is in 17° 30′ N. lat., and 3° W. long.

This long belt of never fading vitality, which has its large lakes, poisonous swamps, deep forests of gigantic trees, and vast solitudes in which no white man ever trod, is of small width compared with its length. In receding from the mountains the moisture becomes less and the soil gradually worse, sufficing only to produce grass for the flocks of the wandering Bedouin. At last a hideous barren waste begins, which extends northwards 800 m. in unvaried desolation to the grassy steppes at the foot of the Atlas; and for 1000 m. between the Atlantic and the Red Sea the nakedness of this blighted land is unbroken but by the valley of the Nile and a few oases in its neighbourhood.

In the W. about 760,000 sq. m., an area equal to that of the Mediterranean Sea, and, in some parts, of a lower level, is covered by the trackless sands of the Sahara Desert, which is even prolonged for miles into the Atlantic Ocean in the form of sand banks. This desert is alternately scorched by heat and pinched by cold. The wind blows from the E. 9 months in the year; and at the equinoxes it rushes in a hurricane, driving the sand in clouds before it, producing the darkness of night at midday, and overwhelming caravans of men and animals in common destruction. Then the sand is heaped up in waves ever varying with the blast; even the atmosphere is sand. The desolation of this dreary waste, boundless to the eye as the ocean, is terrific and sublime; the dry heated air is like a red vapour, the setting sun seems to be a volcanic fire, and at times the burning wind of the desert is the blast of death. There are many salt lakes to the N., and even the springs are of brine; thick incrustations of dazzling salt cover the ground, and the particles, carried aloft by whirlwinds, flash in the sun like diamonds.

Sand is not the only characteristic of the desert; tracts of gravel and low bare rocks occur at times, not less barren and dreary; but on the eastern and northern borders of the Sahara

fresh water rises near the surface, and produces an occasional oasis where barrenness and vitality meet. The oases are generally depressed below the level of the desert, with an arenaceous or calcareous border enclosing their emerald verdure like a frame. The smaller oases produce herbage, ferns, acacias, and some shrubs; forests of date palms grow in the larger, which are the resort of lions, panthers, gazelles, reptiles, and a variety of birds.

In the Nubian and Libyan deserts, to the E. of the Sahara, the continent shelves down towards the Mediterranean in a series of terraces, consisting of vast level sandy or gravelly deserts, lying E. and W., separated by low rocky ridges. This shelving country, which is only 540 ft. above the sea at the distance of 750 m. inland, is cut transversely by the Nile, and by a deep furrow parallel to it, in which there is a long line of oases. This furrow, the Nile, and the Red Sea, which is nearly parallel to both, are flanked by rocky eminences which run N. from the table-land.

On the interminable sands and rocks of these deserts no animal —no insect—breaks the dread silence; not a tree nor a shrub is to be seen in this land without a shadow. In the glare of noon the air quivers with the heat reflected from the red sand, and in the night it is chilled under a clear sky sparkling with its host of stars. Strangely but beautifully contrasted with these scorched solitudes is the narrow valley of the Nile, threading the desert for 1000 m. in emerald green, with its waters foaming with rapids among wild rocks, or quietly spreading in a calm stream amidst fields of corn and the august monuments of past ages.

At the distance of a few days' journey W. from the Nile, over a hideous flinty plain, lies the furrow already mentioned, trending to the N., and containing the oases of Darfur, Selime, the Great and Little Oases, and the parallel valleys of the Natron Lakes, and Bahr Belama or the 'Dry River.' The Great Oasis, or Oasis of Thebes, is 120 m. long and 4 or 5 m. broad; the Lesser Oasis, separated from it by 40 m. of desert, is of the same form. Both are rich in verdure and cultivation, with villages amid palm groves and date plantations, mixed with the ruins of remote antiquity, offering scenes of peaceful and soft beauty contrasted with the surrounding gloom. The Natron Lakes are in the northern part of the valley of Nitrùn, 35 m. W. of the Nile; the southern part is a beautiful retired spot, that became the retreat of Christian monks in the middle of the second century, and at one time contained 360 convents, of which only 4 remain; from these some ancient valuable manuscripts have been obtained.

Another line of oases runs along the latitude of Cairo, with freshwater lakes, no less fertile than the preceding. In one of them are the ruins of the Temple of Jupiter Ammon.

Hundreds of miles on the northern edge of the desert, from the Atlantic along the southern foot of the Atlas to the Great Syrtis, are pasture lands without a tree—an ocean of verdure. At the Great Syrtis the Sahara reaches the shores of the Mediterranean; and, indeed, for 1100 m. between the termination of the Atlas and the little table-land of Barca, the ground is so unproductive that the population only amounts to about 30,000, and these are mostly wandering tribes who feed their flocks on the grassy steppes. Magnificent countries lie along the Mediterranean coast N. of the Atlas, susceptible of cultivation. History, and the ruins of many cities, attest their former splendour; even now there are many populous commercial centres, and much grain is raised, though a great part of these valuable kingdoms is badly cultivated or not cultivated at all.

§ 10. **Geological Notice.**—The base of the sandy parts of North Africa is stiff clay; in Lower Nubia, between the parallels of Assouan and Esneh, red and white granite prevail, followed by argillaceous slates and sandstone; Middle Egypt is calcareous, for the great band of *nummulite*[1] limestone, so ably traced by Sir R. Murchison over nearly a third of the globe, from the Bay of Biscay to the shores of Aracan, crosses Africa between the parallels of 16° and 20° N. lat., and lower down the surface is covered by the alluvial deposits of the Nile.

It would appear that S. Africa, though similar in its unbroken surface and peninsular shape to South America, bears no resemblance to it in other respects, but has a great analogy to the Deccan in its triangular form, its elevated platform, and in the position of its encompassing mountain chains. Besides, there is evidence that the Tertiary strata on the table-land, as in the Deccan, have been the basin of a great freshwater lake.

The prodigious extent of desert is one of the most extraordinary circumstances in the structure of the old continent. A zone of almost irretrievable desolation of at least 120 degrees of longitude prevails from the Atlantic Ocean across Africa and through Central Asia almost to the shores of the Pacific, because this long tract is flanked by an almost continuous chain of mountains and

---

[1] *Nummulites* (Lat. *nummus* = 'money;' and λίθος = 'a stone') are fossils of a flattened form resembling small coins. These belong to the tribe of *Rhizopoda*, and are common in the early Tertiary period.

table-lands which drain the prevailing winds of their moisture. There are also many large districts of the same sterile nature in Europe; and if to these sandy plains the deserts of Siberia be added, together with all the barren and rocky mountain tracts, the quantity of unproductive land in the Old World is prodigious. The quantity of salt on the sandy plains is great, and proves that they have been part of the bed of the ocean or of inland seas at no very remote geological period. The low lands round the Black and Caspian Seas, and the Lake of Aral, seem to have been the most recently raised from the sea, from the great proportion of shells in them identical with those now existing in these seas. The same may be said of the Sahara Desert, where salt and recent shells are plentiful.

CHAPTER IX.

THE CONTINENT OF AMERICA.

§ 1. **General View of the American Continent.**—Some thinner portion of the crust of the globe under the meridians that traverse the continent of America, from Cape Horn to the Arctic Ocean, must have yielded to the expansive forces of the subterranean fires, or been rent by contraction of the strata in cooling. Through this the Andes have arisen, producing the greatest influence on the form of the continent, and the peculiar simplicity that prevails in its principal mountain systems, which, with very few exceptions, have a general tendency from N. to S. The continent is nearly 10,000 m. long, and, consisting of two great peninsulas joined by a long narrow isthmus, is divided by nature into South, Central, and North America; yet these three are connected by the mighty chain of the Andes, and its continuation, the Rocky Mountains running parallel to the Pacific from within the Arctic nearly to the Antarctic circle. In this course every variety of climate is to be met with, from the rigour of polar congelation to the scorching heat of the torrid zone; while the mountains are so high that the same extremes of heat and cold may be experienced in the journey of a few hours from the burning sands which form the coasts of Peru to the snow clad peaks that tower above them. In this long chain there are three distinct varieties of character, nearly, though not entirely, corresponding to the three natural divisions of the continent. The Andes of South America differ materially from those of Central America

and Mexico, while both are dissimilar to the North American prolongation of the chain.

§ 2. **Mountain Systems of South America; the Andes.** —The greatest length of South America from Cape Horn to the Isthmus of Panama is about 4550 m. The continent is very narrow at its southern extremity, but increases in width northwards to the latitude of Cape San Roque on the Atlantic, between which and Cape Blanco on the Pacific it attains its greatest breadth, of nearly 3200 m. It consists of three mountain systems, separated by the basins of three of the greatest rivers in the world. The Andes run along the western coast from Cape Horn to the Isthmus of Panama, in a single chain of inconsiderable width, but majestic height, dipping rapidly to the narrow plains on the Pacific, but descending on the E. by huge spurs or offsets, and deep valleys, to plains of vast extent, whose level is for hundreds of miles as unbroken as that of the ocean by which they are bounded. Nevertheless two detached mountain systems rise from these plains, one in Brazil between the Rio de la Plata and the River Amazon; the other, that of Parima and Guiana, between the River Amazon and the Orinoco.

The great chain of the *Andes*[1] first raises its crest above the waves of the Antarctic Ocean in the majestic sombre mass of Cape Horn, the southernmost point of the archipelago of Tierra del Fuego.[2] This group of mountainous islands, equal in size to Great Britain, is separated from the mainland by the Strait of Magellan. The islands are penetrated in every direction by bays and narrow inlets of the sea, or fjords, ending often in glaciers fed by the snow on the summits of mountains 6000 ft. high. Peat mosses cover the higher declivities of these mountains, and their flanks are clothed with densely entangled forests of brown beech, which never lose their dusky leaves, producing altogether a savage and melancholy landscape. The mountains which occupy the western side of this cluster of islands sink down in extensive plains towards the east, like the continent itself, of which the archipelago is but the southern prolongation.[3]

---

[1] The origin and meaning of the name 'Andes' are not known; *Anta*= 'a Tapir;' *Antis* the name of one of the mountain tribes; *Anta*='metal or copper;' and the Spanish *Andenes* have been variously supposed to give rise to the name.

[2] *Tierra del Fuego*='the land of fire.'

[3] The surveys of the late Admirals King and Fitzroy, Darwin's 'Journal of a Naturalist,' Dr. Pöppig's 'Travels in South America,' are the authorities from which the author has drawn for the account of Tierra del Fuego, Patagonia, and Chile; Humboldt, Pentland, Pöppig and Meyer, of Berlin, for Peru and the Andean chain to the Isthmus of Panama.

The Pacific washes the very base of the Patagonian Andes for about 1000 m., from Cape Horn to the 39th parallel of S. latitude. The whole coast is lined by a succession of archipelagoes and islands, separated from the iron bound shores by narrow arms of the sea, which, in the more southern part, are in fact profound longitudinal valleys of the Andes filled by the ocean, so that the islands running parallel to the axis of these mountains are but the summits of an exterior range rising above the sea.

The coast itself for 650 m. is girt by walls of granite rock, which sink into unfathomable depths, torn by long crevices or fjords similar to those on the Norwegian shore, and ending in tremendous glaciers, whose masses, falling with a crash like thunder, drive the sea in sweeping breakers through these chasms. The islands and the mainland are thickly clothed with forests, which are of a less sombre aspect as the latitude decreases; and more to the N. there are fertile plains inhabited by a rude people, but capable of supporting large populations, and into which Chilian civilisation is advancing.

§ 3. **The Chilian Andes.**—Between the Pass of Chacabuco, N. of Santiago, the capital of Chile, and the archipelago of Chiloe, a chain of hills, composed in general of granite rocks, borders the coast; between which and the Andes exists a longitudinal valley, well watered by the rivers descending from the central chain, and which constitutes the most fertile portion, nay, the garden of the Chilian Republic—the rich provinces of Santiago, Talca, Maule, Nuble, and Concepcion. This longitudinal depression may be considered as a prolongation northwards of the strait that separates Chiloe from the mainland. Many peaks of the Andes enter within the limits of perpetual snow, between the 40th and 31st parallels; some of which are active volcanoes. In lat. 32° 39′ S. rises the Nevado of Aconcagua (23,910 ft.), which towers over the Chilian village of the same name, and is clearly visible from Valparaiso. Although designated as a volcano, a term generally applied in Chile to every elevated and snowy peak, it offers no trace of modern igneous origin. It appears to be composed of a species of porphyry generally found in the centre of the Chilian chain. And in the same group, but farther S., lies the Nevado of Tupungato (20,269 ft.). The line of perpetual snow makes a remarkable bend in Chile; in lat. 33° 8′ S. it is 12,780 ft. above the sea level: 7 degrees farther S., on the parallel of Valdivia, it sinks to 8300: and at Copiapo it rises to 13,800 ft. There is a line of railway being constructed by way of Rosario and Cordova, which is meant soon to connect Buenos Ayres on the Atlantic with Valparaiso on the Pacific.

About the latitude of Concepcion the dense forests of araucarias

and of other semitropical plants cease with its humid equable climate; and as no rain falls in Central Chile for nine months in the year, the brown, purple, and tile red hills and mountains are only dotted here and there with low trees and bushes; very soon, however, after the heavy showers have moistened the cracked ground, it is covered with a beautiful but transient flora. In some valleys it is more permanent and of a tropical character, mixed with Alpine plants.[1] In Northern Chile rain falls only once in two or three years, the consequence of which is sterility on the western precipitous and unbroken descent of the Andes: on the E., two secondary groups separate from the Central Cordillera, which extend 300 or 400 m. into the plains, are wooded to a great height. The Sierra de Cordova, the most southern of these, commences between the 33rd and 31st parallels, and extends in the direction of the Pampas (= *Treeless Plains*); more to the N. the mountains of Salta and Jujuy stretch from the valley of Catamarca and Tucuman towards the Rio Vermejo, one of the tributaries of the Rio de la Plata.

To the N. of Chile succeeds the district of Atacama, which covers 108,000 sq. m., has a population of upwards of 100,000, and belongs partly to Chile and partly to Bolivia. It is a rocky and rugged tract almost destitute of vegetation, but very rich in copper and silver. The chief town, Copiapo, contains 11,432 inhabitants. The valley of Atacama is about 7400 ft. above the sea; in the Andes W. of it rise several very elevated peaks, one of which, Hlaska, 19,600 ft. high, is an active volcano, constantly emitting smoke from its summit.

§ 4. **The Peruvian Andes.**—The chain takes the name of the Peruvian Andes about 24° S. lat., and is separated from the Pacific by a range of hills composed of crystalline rocks, parallel to the sea coast, and by an intervening sandy desert, seldom above 60 m. broad, on which rain scarcely ever falls, where bare rocks pierce through the moving sand. The width of this coast region is nearly the same as the Isthmus of Panama; but damp luxuriant forests, full of orchidaceous plants, begin to show themselves about the latitude of Payta, and continue northwards through the provinces of Guayaquil, Esmeraldas, and Darien.

From their southern extremity to the Nevado of Chorolque, in 21° 30′ S. lat., the Peruvian Andes form one grand and continuous range of mountains; but N. of that peak the chain divides into two longitudinal ridges, which enclose a series of valleys or tablelands, forming so many basins, separated at various points by

---

[1] Dr. Pöppig's 'Travels.'

transverse groups or mountain knots, or by single ranges crossing between them like dykes, a structure that prevails to Pasto, 1° 13′ N. lat.

§ 5. **South American Table-lands.**—Unlike the table-lands of Asia at great elevations, where cultivation is confined to the more sheltered spots, or those still lower in Europe, which are only fit for pasture, these lofty regions of the Andes yield exuberant crops of every kind of European grain, and have many populous cities enjoying the luxuries of civilised life, with universities, libraries, civil and religious establishments, at altitudes equal to that of the Peak of Teneriffe (12,182 ft.). Villages are situated and mines are worked at heights as great or even greater than the top of Mont Blanc.[1] This state is not limited to the present times, since these table-lands were made the centre of civilisation by a race of men who 'bear the same relation to the Incas and the present inhabitants that the Etruscans bear to the ancient Romans and to the Italians of our own days.'

The table-land or valley of the Desaguadero, one of the most remarkable of these basins, has an altitude of 12,900 ft. and a breadth varying from 30 to 60 m.: it stretches 400 m. between the two parallel chains of the Andes, and between the transverse mountain groups of Lipez, in 20° S. lat., and the great mountain knot of Vilcañota, which, extending from E. to W., shuts in the valley on the N.W.; it occupies an area three times as large as Switzerland, some of the snowy peaks rising 8300 ft. above the surface of the table-land, from which an idea may be formed of the gigantic scale of this portion of the Andes. This valley is bounded on each side by the two grand chains of the Peru-Bolivian Andes: that on the W. is the Cordillera of the coast; the range on the E. is the Bolivian Cordillera, properly speaking, called in its N.W. prolongation the Cordillera Real.[2] These two rows of mountains lie so near to each other that the whole breadth of the table-land, including both, is only 226 m. All the snowy peaks of the Cordilleras of the coast are either active volcanoes or of igneous origin, and are all situated near the maritime declivity of the chain; consequently, the descent to the shores of the Pacific is everywhere very abrupt. The eastern Cordillera, which begins near the metalliferous mountain of Potosi, is below the level of perpetual snow to the S., but its northern portion contains the three peaked mountains of the Nevado of Sorata (24,812 ft.), of Supäíwasi

---

[1] The celebrated silver mines of Potosi (16,150 ft.) were, until within the last fifty years, worked to the very summit of that metalliferous mountain.

[2] Humboldt and Pentland.

and Illimani (21,338 ft.), and is one of the most magnificent portions of the Andes. The snowy part begins with the gigantic mass of Illimani, whose serrated ridges are elongated in the direction of the axis of the chain. The lowest glacier on its southern slope does not descend below 16,500 ft., and the valley of Tortoral, a mere gulf in which Vesuvius might stand, comes between Illimani and the Nevado of La Mesada, from whence the eastern Cordillera runs to the N.W. in a continuous line of snow clad peaks to the group of Vilcañota, where it unites with the western. The sharp and serrated chain on the E. forms a striking contrast with the conical and dome shaped Cordillera of the coast. All the rivers and streams that rise on the E. side of the Cordillera of the coast flow to the affluents of the Amazon, through the deep gorges in the eastern Cordillera between Illimani and the Nevado of Sorata.

The valley of the Desaguadero, occupying 150,000 sq. m., has a considerable variety of surface; in the S., throughout the mining districts, it is cold and unproductive. Potosi, the highest city in the world, stands on the N. declivity of the Cerro de Potosi, at an elevation of 13,280 ft. Chuquisaca or Sucre, the capital of Bolivia, containing 23,979 inhabitants, lies to the N.E. of Potosi, in the midst of a cultivated district. The northern part of the valley is populous, and produces barley, potatoes, and in sheltered situations even wheat, and maize; and the Lake of Titicaca, twenty times as large as the Lake of Geneva, fills the N.W. portion of this great basin. The islands and shores of this lake still exhibit ruins of gigantic magnitude, monuments of a people more ancient than the Incas. The modern city of La Paz (pop. 76,372), a few leagues from its southern shores, stands in the bottom of a deep ravine, on each side of an impetuous torrent, descending from the neighbouring snowy peaks, having in full view the vast Nevado of Illimani to the E.S.E., at a distance of 21 m.

Many offsets diverge from the eastern side of the Bolivian Cordillera, which terminate in the great plains of Chiquitos and Paraguay; the most important is the Cordillera of Yuracaraës, which bounds the rich valley of Cochabamba on the N., and ends near the town of Santa Cruz de la Sierra.

There are some fertile valleys in the snow capped group of Vilcañota and Cuzco. The city of Cuzco (pop. 48,000) was the capital of the empire of the Incas: it still contains numerous ruins of that dynasty, among which the remains of the Temple of the Sun, and the Cyclopean fortress that towers over it to the N., still mark its former splendour. Four ancient Peruvian roads led from Cuzco to the different parts of the empire, little inferior in many respects to the old Roman ways: all crossing mountain passes

higher than the summit of the Peak of Teneriffe. On the northern prolongation of the chain in lat. 11° S., encircled by the Andes, is the elevated plain of Bombon (14,000 ft.), near the celebrated silver mines of Pasco. In it is situated the Lake of Lauricocha, which may be considered, from its remoteness, as one of the sources of the Amazon. There are many small lakes on the table-lands and high valleys of the Andes, some even within the range of perpetual snow. They are very cold and deep, often of the purest sea green colour.

§ 6. **Transverse Ranges of the Andes.**—The chain of the Andes is divided into three ranges of mountains running from S. to N. in the transverse group or mountain knots of Pasco and Huanuco, which shuts in the valley of Bombon between the 11th and 10th parallels of S. latitude: that in the centre separates the wide fertile valley of the Upper Marañon from the still richer valley of the Huallaga, whilst the more eastern forms the barrier between the latter and the tropical valley of the Yucayali. The western chain alone attains the limit of perpetual snow, and, if we except the Nevado of Huaylillas, in 7° 50′ S., no mountain N. of this for nearly 400 m. to the Andes of Quito reaches the snow line.

In lat. 4° 50′ S. the Andes form the mountain knot of Loja, celebrated for its forests, in which the Cinchona or Peruvian bark was first discovered. From this knot the chain divides into two great longitudinal ridges or Cordilleras, in an extent of 350 m., passing through the republic of the Equator to the mountain group of Los Pastos in that of New Granada. These ridges enclose a great longitudinal basin, which, divided by the cross ridges of Assuay and Chisinche into three portions, forms the valleys of Cuenca, La Tapia, and Quito. The plain of Quenca offers little interest; that of La Tapia is magnificent; whilst the valley of Quito is one of extraordinary beauty: on either side rise a series of snow capped peaks, as much celebrated in the history of science as the valley itself is in that of the aboriginal races of the New World. Here the energies of volcanic action have been studied with the greatest advantage; here, more than 100 years ago, was executed that measurement of an arc of the meridian which afforded the most accurate data at the time towards the determination of the mass and form of our planet, and which has reflected eternal honour on the body with which it originated, the French Academy of Sciences; and celebrity on the names of Bouguier, La Condamine, Juan, Ulloa, and Godin, who conducted it on the part of the crowns of France and Spain.

The Cordillera which hems in the valley of Quito on the E. contains the snow capped peaks of Antisana (19,137 ft.), Cotopaxi,

(19,500 ft.), Tungaragua, and Sangay. The western range includes the gigantic Chimborazo (21,424 ft.), which may be seen from the coasts of the Pacific, and the pyramidal peak of Illinissa, the wreck of an ancient volcano. As the Illinissa is seen from the ocean, its height was measured by the direct observations of the French Academicians, whence the elevation of the valley of Quito, and of the other peaks that encircle it, was deduced, as well as the earliest approximate value of the barometrical coefficient. North of Chimborazo, and near it, is the Carguäirazo; and close to the city of Quito rises the scarcely less celebrated volcano of Pichincha (15,924 ft.); whilst the Nevado of Cayambe (19,535 ft.)—whose summit is traversed by the equator—perhaps the greatest and most remarkable landmark on the earth's surface, closes the N.E. extremity of this great Andean depression.

The valley of Quito, one of the finest in the Andes, is 200 m. long and 30 wide, with a mean elevation above the sea of 10,000 ft., and bounded by the most magnificent series of volcanic mountains in the New World. A peculiar interest is attached to two of the many volcanoes in the parallel Cordilleras that flank it. The beautiful snow clad cone of Cayambe Urcu closes it on the north; and on the western side the cross still stands on the summit of Pichincha, which served as a signal to Bouguier and La Condamine in their memorable measurement of the equatorial arc of the meridian.[1]

Some parts of the plain of Quito to the S. are sterile, but the soil generally is fertile, and perpetual spring clothes it with exuberant vegetation. The city of Quito (pop. 76,000), at the base of Pichincha, lies at an elevation of 9520 ft. It is regularly and well built; the churches are rich; it possesses a university, and many of the comforts and luxuries of civilised life, in a situation of unrivalled grandeur. Thus, on the very summit of the Andes there is a world by itself, with its mountains and its valleys, its lakes and rivers, populous towns and cultivated fields. Many monuments of the Incas are still found in good preservation in these plains, where the scenery is most noble—eleven volcanic cones are visible from one spot. Although the Andes are inferior in height to the Himalaya, yet the domes of trachyte, the truncated cones of the active volcanoes, and the serrated ruins of those that are extinct, mixed with the bold features of primary mountains, give an infinitely greater variety to the scene, while the smoke, and very often the flame, issuing from these regions of perpetual snow, increase its sublimity. Stupendous as these mountains appear even from the plains of the table-land, they are merely

[1] Humboldt.

the inequalities of the tops of the Andes, the serrated summit of that mighty chain.

Between the large group of Los Pastos, containing several active volcanoes, and the group of Las Papas, in 2° N. lat., the bottom of the valley is only 6920 ft. above the sea; and N. of the latter mountain knot the crest of the Andes splits into 3 Cordilleras, which diverge, not again to unite. The most westerly of these, the range of Choco, which may be considered the continuation of the great chain, separates the valley of the River Cauca from the Pacific; it is only 5000 ft. high, and the lowest of the three. Though but 20 m. broad, it is so steep and so difficult of access that travellers cannot cross it on mules, but are carried on men's shoulders; it is rich in alluvial deposits of gold and platinum. The central branch, or Cordillera of Quindiu, runs due N. between the valleys of the Magdalena and Cauca, rising to a great height in the volcanic peak of Tolima (18,130 ft.). The last two chains are united by the mountain knot of Antioquia, of which little more is known than that it forms two great masses, which, after separating the streams of the Magdalena, Cauca, and Atrato, trends to the N.W., greatly reduced in height, and with the chain of Choco forms the low mountains of the Isthmus of Panama. The most easterly of the three Cordilleras, called the Sierra de la Summa Paz, spreads out on its western declivity into the table-lands of Bogota, Tunja, &c. &c., the ancient Cundinamarca, which have an elevation of about 9000 ft.; whilst on its eastern slope are the sources of the Rivers Guaviari and Meta, the head waters of the Orinoco. The great natural crevice of Icononzo occurs in the path leading from the city of Bogota to the banks of the Magdalena. It was probably formed by an earthquake, and is like an unfilled mineral vein, across which are two natural bridges: the lowest is composed of stones that have been jammed between the rocks in their fall.[1] This Cordillera comprises the Andes of Cundinamarca and Merida, and runs in a N.E. direction through New Granada to the 10th northern parallel, where it joins the coast chain of Venezuela or Caracas, and ends at Cape Paria in the Caribbean Sea, or rather at the E. extremity of the Island of Trinidad. This coast chain is so majestic and beautiful that Baron Humboldt says it is like the Alps rising out of the sea without their snow. The insulated group of Santa Martha (19,000 ft.), deeply covered with snow, stands on an extensive plain between the delta of the Magdalena and the sea lake of Maracaybo, and is a landmark to mariners far off in the Caribbean Sea.

§ 7. **Passes of the Andes.**—The Passes over the Chilian Andes are numerous; the double one of the Portillo (14,365 ft.),

---

[1] Humboldt.

leading from Santiago to Mendoza, is the highest; it crosses two ridges, one of which is so high that vegetation ceases far below its summit. Those in Peru are higher, though very few reach the snow line. In Bolivia the mean elevation of the passes in the western and eastern Cordillera is 14,892 and 11,422 ft. respectively. Guasco (15,732 ft.), leading from Sorata to the auriferous valley of Tipuani, is perhaps the highest in Bolivia. The Pass of Quindiu, in New Granada, though not so high, is the most difficult of all across the Andes; but those crossing the mountain knots from one table-land to another are the most dangerous. The road over the Paramo del Assuay, in the plain of Quito, is 15,520 ft. high; and travellers not unfrequently perish from cold winds in attempting it.

§ 8. **Climate of the Andes.**—On the W. side of the Peruvian Andes little or no rain falls, except at their most southern extremity; and scanty vegetation appears only on spots or in small valleys watered by streams from the Andes. Excessive heat and moisture combine to cover the E. side and its offsets with tangled forests of large trees and dense brushwood. This exuberance diminishes as the height increases, till at last the barren rocks are covered only by snow and glaciers. In the Andes near the equator glaciers descending below the snow line are unknown. The steepness of the declivities and the dryness of the air at such great elevations prevent any accumulation of infiltrated water: the annual variations of temperature, besides, are small. Nothing can surpass the desolation of these regions, where nature has been shaken by terrific convulsions. The dazzling snow fatigues the eye: the huge masses of bold rock, the mural precipices, and the chasms yawning into dark unknown depths, strike the imagination; while the crash of the avalanche or the rolling thunder of the volcano startles the ear.

In the elevated plains between the transverse groups, such as that of Bombon, however pure the sky, the landscape is lurid and colourless; the dark blue shadows are deeply defined, and from the thinness of the air it is hardly possible to make a just estimate of distance. Changes of weather are sudden and violent; clouds of black vapour arise, and are carried by fierce winds over the barren plains; snow and hail are driven with irresistible impetuosity; and thunderstorms come on, loud and awful, without warning. Notwithstanding the thinness of the air, the crash of the peals is quite appalling; while the lightning runs along the scorched grass, and, sometimes issuing from the ground, destroys a team of mules or a flock of sheep at one flash.[1]

---

[1] Pöppig.

Currents of warm air are occasionally met with on the crest of the Andes—an extraordinary phenomenon on such gelid heights, which is not yet explained; they generally occur two hours after sunset, are local and narrow, not exceeding a few fathoms in width, similar to the equally partial blasts of hot air in the Alps. A singular instance, probably of earth light, occurs in crossing the Andes from Chile to Mendoza. On this rocky scene a peculiar brightness occasionally rests, a kind of indescribable reddish light, which vanishes during the winter rains, and is not perceptible on sunny days. Dr. Pöppig ascribes the phenomenon to the dryness of the air: he was confirmed in his opinion from afterwards observing a similar brightness on the coast of Peru, and it has also been seen in Egypt.

The Andes S. of Peru descend to the eastern plains by a series of cultivated terraces, as those of Tucuman, Salta, and Jujuy, in the Republic of La Plata. That of Tucuman is 2500 ft. above the sea. In Peru the descent to the E. is more precipitous; all the streams flow to the plains down stupendous ravines or *quebradas*, the heights dividing one watercourse from another being so steep and lofty that the traveller has to make a wide circuit to pass from valley to valley. In descending by the banks of the rivers, the change is rapid, from the cool region of scanty vegetation down to the sweltering plains, where grow the banana and sugar cane in tropical luxuriance. Light mists hang over the forest landscape in early morning, and the gleam of leaping cascades from the neighbouring heights adds to the glory of the scene. Farther N., on the Huallaga, the Andes end abruptly like a steep wall, and the transition is sudden from the region of mountains to that of the Amazon plains, which extend almost without inequalities from the foot of the mountain wall to the Atlantic.

§ 9. **Low Lands East of the Andes.**—The low lands E. of the Andes are divided by the table-lands and mountains of Guiana and Brazil into three parts of very different aspect, viz. the Deserts and Pampas of Patagonia and Buenos Ayres; the Forest Plains of the Amazon; and the Llanos, or Grassy Steppes, of the Orinoco. The eastern table-lands nowhere exceed 2500 ft. in elevation. The plains are so low and flat, especially at the foot of the Andes, that a rise of 1000 ft. in the Atlantic Ocean would submerge more than half the continent of South America. The mountains of Guiana consist of two distinct systems, which lie respectively in the N.W. and S.E. of this region. The chief range of the N.W. system is the Sierra Nevada de Merida, a branch of the Andes, which, on reaching the coast, turns eastwards and runs near the sea to Point Parina, under the name of the Sierra Costanera. The

culminating point of these mountains lies near the town of Merida (whence the name of the range), and reaches an elevation of 15,026 ft. above the sea.

The S.E. system or mountains of Parima is a group scattered over a table-land not more than 2000 ft. above the sea, which extends 600 or 700 m. from E. to W., between the Rivers Orinoco, Rio Negro, Amazon, and the Atlantic Ocean. It is quite unconnected with the Andes, being 80 leagues E. from the mountains of New Granada. It begins 60 or 70 m. from the coast of Venezuela, ascends by four successive terraces to undulating plains, which reach to within one or two degrees of the equator, and is twice as long as it is broad.

Seven chains, besides groups of mountains, traverse the table land from W. to E., of which the chief is the Sierra del Parima. Beginning at the mouth of the Meta, it crosses the plains of Esmeralda to the frontier of Brazil. This chain is not more than 600 ft. high, is everywhere abrupt, and forms the watershed between the tributaries of the Amazon and of the Orinoco. The Orinoco rises on the N. side of the Sierra del Parima, and in its circuitous course over the plains of Esmeralda it breaks through that chain and the parallel one of the Maypures 36 m. to the S.: dashing with violence against the transverse shelving rocks and dykes, it forms the magnificent series of rapids and cataracts of Maypures and Atures, from whence the Parima Mountains have got the name of the Cordillera of the Cataracts of the Orinoco. The chain is of granite, which forms the banks and fills the bed of the river, covered with luxuriant tropical vegetation, especially palm forests. In the district of the Upper Orinoco, near Chirischana, there is a granite rock which emits musical sounds at sunrise, like the notes of an organ, occasioned by the difference of temperature of the external air and that which fills the deep narrow crevices with which the rock is everywhere torn. Something of the same kind occurs at Mount Sinai, but the sound is there caused by the friction of moving sand.[1]

The other parallel chains that extend over the table-land in Venezuela and Guiana, though not of great height, are rugged, and often crowned with mural ridges: they are separated by flat savannahs, generally barren in the dry season, but after the rains covered with a carpet of long emerald green grass, mixed with flowers. The vegetation in these countries is beautiful beyond imagination. The regions of the Upper Orinoco and Rio Negro, and of almost

[1] Humboldt.

all the mountains and banks of rivers in Guiana, are clothed with majestic and impenetrable forests, whose moist and hot recesses are the favourite abode of the singular and beautiful family of the Orchideæ.

Although all the mountains of the system of Parima are wild and rugged, they are not high. The inaccessible peak of the Cerro Duida, which rises insulated 7155 ft. above the plain of Esmeralda, is the culminating point, and one of the highest mountains in South America E. of the Andes. The fine savannahs of the Rupununi were the country of romance in the days of Queen Elizabeth. South of Pacaraima, near an inlet of the river, the far famed city of Manoa was supposed to stand, the object of the unfortunate expedition of Sir Walter Raleigh; about 11 m. S.W. of which is situate the Lake Amucu, 'the Great Lake with golden banks'—great only during the periodical floods.[1] Gold has been rediscovered in this region between the Imataca Hills and the Cuyuni River, thus affording some justification of the reports which attracted our great countryman.

§ 10. **Table-land and Mountains of Brazil.**—On the southern side of the basin of the River Amazon lies the table-land of Brazil, having a mean height of about 2500 ft., which occupies half that empire, together with part of the republics of the Rio de la Plata, and Uruguay. Its form is triangular, the apex being at the confluence of the Rivers Mamoré and Beni; the base extending near the shores of the Atlantic, from the mouth of the Rio de la Plata to within 3 degrees of the equator. It is difficult to define the limits of this vast territory, but some idea may be formed of it by following the directions of the rapids and cataracts of the rivers descending from it to the plains around. Thus a line drawn from the fall of the river of the Tocantins, in 3° 30′ S. lat., to the cataracts of the Madeira, in 8° S. lat., will nearly mark its northern boundary; from thence the line would run S.W. to the junction of the Mamoré and Beni; then turning to the S.E. along the ridges of mountains called the Cordillera Geral, and Sierra Parecis, it would proceed S. to the cataract of the Parana, called the Sete Quedas, in 24° 30′ S. lat.; and lastly from thence, by the great falls of the River Iguassu, to the Morro de Santa Martha, in latitude 28° 40′ S. of the Island of St. Catherine.

Chains of mountains, nearly parallel, extend from S.W. to N.E. 700 m. along the base of the triangle, with a breadth of about 400 m. Of these, the Sierra do Mar, or the 'coast chain,' reaches from the River Uruguay to Cape San Roque, never more distant

---

[1] Humboldt's 'Personal Narrative.'

than 20 m. from the Atlantic, except to the S. of the Bay of Santos, where it is 80. It is the richest botanical region in Brazil. Offsets diverge to the right and left; the granitic peaks of the Corcovado and Tejuco, which form such picturesque objects in that most magnificent of panoramas, the Bay of Rio de Janeiro, are the extremities of one. The parallel chain of Espinhaço, beginning near the town of San Paolo, and the continuous chains of the Serra Frio, forming the western boundary of the basin of the Rio San Francisco, is the highest in Brazil, one of its mountains, Itambe, being 8426 ft. above the sea. All the mountains in Brazil have a general tendency from S.W. to N.E., except the transverse chain of the Sierra dos Vertentes, which rises 60 m. S. of Villa Rica, and runs in a tortuous line to its termination near the junction of the Mamore and Beni. It forms the watershed of the tributaries of the San Francisco and Amazon on the N., and those of the Rio de la Plata on the S.; its greatest height is 3500 ft. above the sea; its western part, the Sierra Parecis, is merely a succession of detached hills. This chain, the coast chain of Venezuela, and the mountains of Parima, are the only ranges in the continent of America that do not lie substantially in a meridional direction.

Forests of magnificent trees, bound together by tangled creeping and parasitical plants, clothe the declivities of the mountains and line the banks of the Brazilian rivers, where the soil is rich and the verdure brilliant. Many of the plains on the table-land bear a coarse nutritious grass after the rains only, others forests of dwarf trees; but vast undulating tracts are always verdant with excellent pasture intermixed with fields of corn. Some parts consist of bare sand and rolled quartz; and the Campos Parecis, N. of the Sierra dos Vertentes, in the province of Matto Grosso, is a sandy desert of unknown extent, similar, but upon a smaller scale, to the Great Gobi on the table-land of Tibet.

CHAPTER X.

SOUTH AMERICA.

§ 1. **Low Lands of South America.**—The southern plains are the most barren of the three great tracts of American low lands: they stretch from Tierra del Fuego over 27 degrees of latitude, or 1900 m., nearly to Tucuman, and the hilly country of Brazil. Palms grow at one extremity, deep snow covers the other many months in the year. This enormous plain, of 1,620,000 sq. m., begins on the eastern side of Tierra del Fuego, where it is a flat

covered with trees, and therefore superior to its continuation on the continent through eastern Patagonia, which, for 800 m. from the land's end to beyond the Rio Colorado, is a desert of shingle.[1] It is occasionally diversified by huge boulders, tufts of brown grass, low bushes armed with thorns, salt lakes, saline incrustations as white as snow, and by black basaltic platforms like plains of iron, at the foot of the Andes, barren as the rest. Eastern Patagonia, however, is not one universal flat, but a succession of shingly horizontal plains at higher and higher levels, separated by long lines of escarpments, the gable ends of the tiers or plains. The ascent is small, for even at the foot of the Andes the highest of these platforms is only 3000 ft. above the ocean. The plains are here and there intersected by a ravine or a stream, the waters of which do not fertilise the blighted soil. The transition from intense heat to intense cold is rapid, and piercing winds often rush in hurricanes over these deserts, shunned even by the Indian, except when he crosses them to visit the tombs of his fathers. The shingle ends a few miles to the N. of the Rio Colorado: there the red calcareous earth of the Pampas begins, covered with coarse tufted grass, without a tree or bush to relieve the view. This country, nearly as level as the sea and without a stone, extends almost to the table-land of Brazil; and for 1000 m. between the Atlantic and the Andes, interrupted only at considerable distances by a solitary umbú, the only tree of this soil, rising like a great landmark. This wide space, though almost destitute of water, is not all of the same description. In the Pampas of Buenos Ayres there are four distinct regions. For 180 m. W. from Buenos Ayres the plains are covered with thistles and lucern of the most vivid green so long as the moisture from the rain lasts. In spring the verdure fades, and a month afterwards the thistles shoot up 10 ft. high, so dense and so protected by spines that they are impenetrable. During the summer the dried stalks are broken by the wind, and the lucern again spreads freshness over the ground. The Pampas, for 430 m. W. of this region, are covered with long tufted luxuriant grass, intermixed with flowers, affording inexhaustible pasture to thousands of horses and cattle. This is followed by a tract of swamps and bogs, to which succeeds a region of ravines and stones; and, lastly, a zone, reaching to the Andes, of thorny bushes and dwarf trees forming a dense thicket. The plains in Entre Rios in Uruguay, those of Santa Fé, and a great part of Cordova and Tucuman, are of sward, with cattle farms. The banks of the Paraná, and other tributaries of the Plata, are adorned with an infinite variety of tropical productions, especially the graceful tribe of palms; and the river islands are bright with orange groves.

1 Admiral P. B. King and Mr. Darwin.

A desert of sand, called El Gran Chaco, exists W. of the Paraguay, the vegetable produce of which is confined to varieties of the aloe and cactus tribes. Adjoining this desert are the Bolivian provinces of Chiquitos and Moxos, covered with forests and jungles, the scene of the most laborious and beneficent exertions of the Jesuit missionaries in the last century towards the civilisation of the aborigines of South America.

The Pampas of Buenos Ayres, 1000 ft. above the sea, sink to a low level along the foot of the Andes, where the streams from the mountains collect in large lakes, swamps, lagoons of great extent, and wide spreading salt marshes. These swamps are swollen to thousands of square miles by the annual floods of the rivers, which also inundate the Pampas, leaving a fertilising coat of mud. Multitudes of animals perish in the floods, and the drought that sometimes succeeds is more fatal. Millions of animals are sometimes destroyed by casual and dreadful conflagrations among the dry grass and thistles.[1]

§ 2. **The Forest of the Amazon.**—The Matto Grosso (= 'Great Forest'), bordering on the River Amazon, forms the second division of the South American low lands. This country is more uneven than the Pampas, and the vegetation is so dense that it can only be penetrated by sailing up the river or its tributaries. The forests not only cover the basin of the Amazon from the Cordillera of Chiquitos to the mountains of Parima, but also its limiting mountain chains, the Sierra dos Vertentes and Parima, so that the whole forms an area of woodland more than 6 times the size of France, lying between the 18th parallel S. lat. and the 7th N.; consequently intertropical and traversed by the equator. There are some marshy savannahs along the margins of the Lower Amazon, and some grassy steppes on the Guiana side of the river; but they are insignificant compared with the virgin forest, which extends 1500 m. in length, varying in breadth from 350 to 800 m. According to Humboldt, the soil, enriched for ages by the spoils of the forest, consists of the richest mould. The temperature in the deep and dark recesses of these primeval woods is much moderated by the shade and cool winds from the sea; but the air is saturated with moisture, and the damp is so excessive that a blue mist rises in the early morning among the huge stems of the trees, and envelopes the entangled creepers stretching from bough to bough. A deathlike stillness prevails during the heat of midday, but at sunrise, and sometimes in the night, the songs of strange birds, and the cries of invisible animals, give some degree of animation to the leafy

[1] Sir Woodbine Parish on Buenos Ayres, and Sir Francis Head's 'Journey over the Pampas.'

wilderness. The anxiety and terror of the animals before a thunder-storm is excessive, and all nature seems to partake in the dread. The tops of the lofty trees rustle ominously, though not a breath of air agitates them; a hollow whistling in the high regions of the atmosphere comes as a warning from the black floating vapour; midnight darkness envelopes the ancient forests, which soon after groan and creak with the blast of the hurricane. The gloom is rendered still more hideous by the vivid lightning and the stunning crash of thunder. Even fishes are affected with the general consternation; for in a few minutes the Amazon rages in waves like a stormy sea.

§ 3. **The Llanos of the Orinoco and Venezuela,** covered with long grass, form the third region of South American low lands, and occupy 350,000 sq. m. between the deltas of the Orinoco and the coast range of Venezuela, level as the surface of the sea. It is possible to travel over these flat plains for several hundred miles without seeing an eminence a foot high. They are twice as long as they are broad; and, as the wind blows constantly from the E., the climate is the more ardent the farther W. These steppes for the most part are destitute of trees or bushes, yet in some places they are dotted with the mauritia and other palm trees. Flat as these plains are, there are in some places two kinds of inequalities; one consists of banks or shoals of grit or compact limestone, 5 or 6 ft. high, perfectly level for several leagues, and imperceptible except on their edges: the other inequality can only be detected by levelling instruments; it is called a 'Mesa,' and is an eminence rising imperceptibly to the height of some fathoms. Small as the elevation is, a mesa forms the watershed from S.W. to N.E., between the affluents of the Orinoco and the streams flowing to the N. coast of Terra Firma. In the wet season, from April to the end of October, the tropical rains pour down in torrents, and hundreds of square miles of the Llanos are inundated by the floods of the rivers. The water is sometimes several feet deep in the hollows, in which so many horses and other animals perish that the ground retains the smell of musk, an odour peculiar to many South American quadrupeds. From the flatness of the country too, the waters of some affluents of the Orinoco are driven backwards by the floods of that river, especially when aided by the wind, and form temporary lakes. When the waters subside, these steppes, manured by the sediment, are mantled with verdure, and produce the pine apple plant, whilst occasional groups of fan palm trees and mimosas skirt the rivers. When the dry weather returns, the grass is burnt up; the air is filled with dust raised by currents occasioned by difference of temperature, even where there is no wind. If by any accident a spark of fire falls on the scorched

plains, a conflagration spreads from river to river, destroying every living creature, and leaves the clayey soil sterile for years till vicissitudes of weather recrumble the bricklike surface into a vegetable-producing earth.

The Llanos lie between the equator and the Tropic of Cancer; the mean annual temperature is about 84° Fahr. The heat is most intense during the rainy season, when tremendous thunderstorms are of common occurrence.

§ 4. **Geological Notice.**—The most remarkable circumstance in the geological features of the South American continent is the vast development of volcanic action, which is confined to the chain of the Andes, where it has acquired a considerable breadth, as in the Peru-Bolivian portion, in the part nearest the sea coast. It would be wrong, however, to say that there are no traces of modern volcanic action at a great distance from the sea.[1] The volcanic vents occur in the Andes in linear groups: the most southern of these is that of Chile, extending from the latitude of Chiloe to that of Santiago, 42° to 33° S.: in this space exist 5 well authenticated craters in ignition—the most southern is the volcano of Llanquihue or Osorno, observed by M. Gay, and the most northern that of Maypu, the fires of which are sometimes seen from the capital of Chile. Between these two are situated those of Villarica, Antuco, and Chillan. The volcano of Antuco was, in 1845, when visited by M. Domeyko, in great activity; its height, as determined by that naturalist, is 8918 ft. only, and the snow line on its sides 7996 ft. above the sea; the volcano of Villarica is 120 m. S., and that of Chillan 80 m. N. of the volcano of Antuco. From the 33rd parallel to the Bolivian frontier there does not appear to be a single volcanic vent; but in the province of Atacama rise the volcanoes of Licancan and Atacama, E. of San Pedro of Atacama, still occasionally in activity. The mountain of Isluga,

[1] Mr. Pentland found a very perfect volcanic crater, with well marked currents of lava issuing from it—a rare occurrence in the higher craters of the Andes—not far from San Pedro de Cacha in the valley of the Yucay (lat. 14° 12′ S., long. 71° 15′ W., and at an elevation of 12,000 ft.), near the ruins of the Temple of the Inca Viracocha, a monument and a locality celebrated in Peruvian legend, the nearest point of the sea coast being 175 m. distant. It is probable that some of the most celebrated mining districts of Alto Peru—Potosi, for instance, situated in porphyry—have been upheaved at a very recent period. Modern volcanic rocks are not wanting in the valley of the Desaguadero; volcanic conglomerates exist in the deep ravines round the city of La Paz, lat. 16° 30′ S.; and the mountain of Litanias, which furnishes the building stone for that Bolivian city (lat. 16° 42′ S., long. 68° 19½′ W.), is composed of a most perfect trachyte, and rises to a height of 14,500 ft. above and at a distance of 160 m. from the Pacific.

in lat. 11′ S., 19° and in the province of Tarapaca, is also an active volcano; but the great centre of volcanic action in this part of the Western Cordillera extends from 18° 10′ S., to 16° 20′ S., where the Andes have changed their direction from being parallel to the meridian to one inclined nearly 45 degrees to that line. The trachytic giant domes of the Andes, Sahama (23,015 ft.), one of the most perfect trachytic pyramids in the Andes, and the Nevado of Chuquibamba, mark the N. and S. limits of this line of vents. Near Sahama are the twin Nevados of Pomarape and Parinacota, one of which appeared to Mr. Pentland still to emit vapours. The group of snowy peaks seen from Arica, the centre of which, the Nevado of Tacora, is in lat. 17° 43′ S., offers a broken down crater, and an active solfatara, on one of its sides. This region was the focus of the great earthquake of August 13, 1868. Between the latitude of Arequipa (16° 24′ S.) and the equatorial group of volcanoes, the Andes do not present a single active crater. This equatorial group extends over a meridional line of 3¼ degrees—between the Peak of Sangay and the volcano of Los Pastos. The most remarkable of these volcanic vents are the Sangay, Tunguragua, and Cotopaxi, all situated in the Cordillera most remote from the ocean. Pichincha was in activity as recently as 1831; and N. of the equator, Imbabura, the volcanoes of Chiles, of Cumbal, of Tuqueres or Los Pastos, of Sotara and Purace, mark the extension of actual volcanic action into the northern hemisphere.

Granite, which seems to be the base of the whole continent, is widely spread to the E. and S.; it appears in Tierra del Fuego and in the Patagonian Andes abundantly, at great elevations, and in Chile and Southern Peru forms the line of hills parallel to the Pacific, wherein are situated the mineral riches of the former republic. Palæozoic rocks abound in the Bolivian Cordillera, the lofty mountains, according to Dr. Forbes, showing uptilted strata of the Silurian epoch; and the carboniferous limestone, with its characteristic fossils, forms in the basin of Titicaca entire islands, amongst others that from which the lake takes its name, one of the earliest seats of Peruvian civilisation. Quartz rock, probably of the Devonian period, is much developed, generally mixed with mica, and rich in gold and specular iron. It sometimes extends several leagues in the western declivities of Peru, 6000 ft. thick.

Fossil shells of different geological periods are found at various elevations, which shows that many upheavings and subsidences have taken place in the chain of the Andes. Mr. Pentland found shells of the Silurian period at a height of 17,500 ft. on the Bolivian Nevado of Antakäua, lat. 16° 21′ S., and those of the carboniferous limestones as high as 14,200 in several parts of Upper Peru. Dr. Darwin supposes that the whole range, after twice

subsiding some thousand feet, was brought up by a slow movement in mass during the Eocene period, after which it sank down once more several hundred feet, to be again uplifted to its present level by a slow and often interrupted motion. These vicissitudes are very perceptible, especially at its southern extremity. Stems of large trees, which Dr. Darwin found in a fossil state in the Uspallata range, on the eastern declivity of the Chilian Andes, now 700 m. distant from the Atlantic, exhibit a remarkable example of such vicissitudes. These trees, with the volcanic soil on which they had grown, had sunk from the beach to the bottom of a deep ocean, from which, after five alternations of sedimentary deposits and deluges of submarine lava of prodigious thickness, the whole mass was raised up, and now forms the Uspallata chain. Subsequently, by the wearing of streams, the embedded trunks have been brought into view in a silicified state, projecting from the soil in which they grew—now solid rock.

'Vast and scarcely comprehensible as such changes must ever appear, yet they have all occurred within a period recent when compared with the history of the Cordillera; and the Cordillera itself is absolutely modern compared with many of the fossiliferous strata of Europe and America.'[1]

From the quantity of shingle and sand in the valleys in the lower ridges, as well as at altitudes from 7000 to 9000 ft. above the present level of the sea, it appears that the whole area of the Chilian Andes has been upheaved by a gradual motion; the coast is now rising in some places by the same imperceptible degrees; it has been sometimes suddenly elevated by small upheavings of a few feet, accompanied by earthquakes, one of the most remarkable of which was that which shook the continent to an extent of 1000 m. on the 20th February, 1835.

On the E. side of the Andes the continent from Tierra del Fuego to the Rio de la Plata appears to have been raised *en masse* by one great elevating force, acting equally and imperceptibly for 2000 m. within the period of the now living race of marine animals, which, embedded in many parts of these plains, still retain even their colours. The gradual upward movement was interrupted by at least eight long periods of repose, marked by the edges of the successive plains, which, extending from S. to N., had formed so many lines of sea coast, as they rose higher and higher between the Atlantic and the Andes. It appears, from the shingle and fossil shells found on both sides of the Cordillera, that the whole S.W. extremity of the continent, and indeed the whole Andean chain, has been rising slowly for a long time. The

[1] Darwin's 'Journal of Travels in South America.'

rise on some parts of the coast of Chile has been at the rate of several feet in a century; but it has diminished eastward, till in the Patagonian plains and Pampas it has been only a few inches in the same time.

The instability of the southern part of the American continent is less astonishing when it is considered that at the time of the great earthquake of 1835 the volcanoes in the Chilian Andes were in eruption contemporaneously for 720 m. in one direction and 400 in another, so that in all probability there was a subterranean lake of molten lava twice as large as the Black Sea below this extremity of the continent.[1]

The terraced plains of Patagonia, which extend for hundreds of miles along the coast, are of Tertiary strata, not in basins, but in one great deposit, above which lies a thick stratum of a white pumiceous substance, extending at least 500 m., a tenth part of which consists of marine infusoria. Over the whole lies the shingle already mentioned, spread along the coast for 700 m. in length, with a mean breadth of 200 m. and 50 ft. thick. These myriads of pebbles, chiefly of porphyry, have been torn from the rocks of the Andes, and water worn, at a period subsequent to the deposition of the Tertiary strata. All the plains of Tierra del Fuego and Patagonia, on both sides of the Andes, are strewed with huge boulders, probably transported by icebergs which had descended to lower latitudes in ancient times than they do now—observations of great interest, which we owe to Dr. Darwin.

The stunted vegetation of these sterile plains was sufficient to nourish several large species of animals, now extinct, even at a period when the species now living in the Patagonian seas existed.

CHAPTER XI.

CENTRAL AMERICA.

§ 1. **General Configuration of Central America.**—Taking the natural divisions of the continent alone into consideration, Central America may be regarded as lying between the Isthmus of Panama and Darien, and that of Tehuantepec, and consequently within the tropical zone. This narrow tortuous strip of land, which unites the continents of North and South America, stretches

---

[1] Darwin's 'Journal of Travels in South America.'

from S.E. to N.W. about 1200 m., varying in breadth from 30 to 300 or 400 m.

As a regular chain the Andes end suddenly at the Isthmus of Panama, but as a mass of high land they continue through Central America and Mexico, in an irregular mass of table-lands and mountain ranges. The high land which forms the central ridge and the watershed between the two oceans is very steep on its western side, and runs near the coast of the Pacific, where Central America is narrow; but to the N., where it becomes wider, it recedes to a greater distance from the shore than the Andes do in any other part between Cape Horn and Mexico. From the survey for the railway across the Isthmus of Panama, the highest point traversed by the road is Baldwin's Summit, 299 ft. above the sea—which it crosses by a tunnel 254 ft. above the same level.

This country consists of 3 distinct groups divided by valleys which run from sea to sea, namely Costa Rica, the group of Honduras and Nicaragua, and the group of Guatemala.[1]

North of the isthmus the plains of Panama, very little raised above the sea, and in some parts studded with hills, follow the direction of the isthmus for 280 m., and end at the Bay of Parita. From thence proceeds the forest covered Cordillera of Veragua, supposed to be 9000 ft. high, but united with the Cordillera of Salamanca, on the western side of which is the gold mine of Tisingal, celebrated by the early historians of the Conquest; the latter Cordillera extends to the elevated table-land of Costa Rica, surrounded by volcanoes, and terminates at the plain of Nicaragua, which, together with its lake, occupies an area of 30,000 sq. m., and forms the second break in the great Andean chain. The lake is only 130 ft. above the Pacific, from which it is separated by a line of active volcanoes. The River of San Juan flows from its S.E. end into the Caribbean Sea, and at its N. extremity it is connected with the smaller Lake of Managua or Leon by the River Panaloya or Tipitapa. By this water line it has been projected to unite the two seas, the distance between them being only 20 m. The high land recommences, after an interval of 170 m., with the Mosquito country and Honduras, which mostly consist of table-lands and high mountains, some of which are active volcanoes. From a recent survey it appears that there is a perfectly practicable route across Honduras through the valleys of the Rivers Humaya and Goascoran, for a railway only 220 m. long, which would connect Port Cortez on the Atlantic with Fonseca on the Pacific, both first rate harbours: a combina-

[1] Johnston's 'Physical Atlas.'

tion so favourable does not exist throughout all Central America for an interoceanic intercourse.

§ 2. **Table-land of Guatemala.**—Guatemala is a table-land intersected by deep valleys, which lies between the plain of Comayagua and the Isthmus of Tehuantepec. It spreads to the E. in the peninsula of Yucatan, which terminates at Cape Catoche, and encompasses the Bay of Honduras with terraces of high mountains. The table-land of Guatemala consists of undulating verdant plains of great extent, 5000 ft. high, and fragrant with flowers. In the S. the cities of Old and New Guatemala are situated 24 m. apart. The portion of the plain on which New Guatemala stands is bounded on one side by the three volcanoes of Pacaya, Fuego, and Agua; which, rising from 7000 to 13,200 ft. above the plain, lie 20 m. from the new city on the S.W., and form a scene of great boldness and beauty. The Volcano de Agua (13,200 ft.), at the foot of which Old Guatemala stands, is a perfect cone, verdant to its summit, and occasionally pouring forth torrents of boiling water and stones. The old city has been twice destroyed by it, and is now nearly deserted on account of earthquakes. The Volcano del Fuego generally emits vapours from one of its peaks; and the Volcano de Pacaya is only occasionally active. The wide grassy plains are cut by deep valleys to the N., where the high land of Guatemala ends in parallel ridges of mountains called the Cerro Pelado, which run from E. to W. along the 94th meridian W., filling half the Isthmus of Tehuantepec, and unite the table-land of Guatemala with that of Mexico.

Though there are large savannahs on the high plains of Guatemala, there are also magnificent primeval forests, as the name of the country implies, Guatemala signifying, in the native language, 'a place covered with trees.' The banks of the River Papian, or Utsumasinta, which flows over the table-land to the Gulf of Mexico, are beautiful beyond description.

§ 3. **The Coast Region.**—The flat region bordering the coast of Central America is generally narrow, and in some places the mountains and high lands come close to the water's edge. The sugar cane is indigenous, and on the low lands on the eastern coast all the ordinary productions of the West Indian islands are raised, besides several that are peculiar to the country.

As the climate is cool on the high lands, the vegetation of the temperate zone is there very luxuriant. On the low lands, as in other countries where heat and moisture are in excess, and where nature is for the most part undisturbed, vegetation is vigorous to rankness: forests of gigantic trees seek the pure air above an impenetrable undergrowth, the rivers empty themselves into the sea

amidst dense masses of jungle with mangroves and reeds 100 ft. high, whilst delightful savannahs vary the scene, and wooded mountains dip into the water.

Nearly the whole coast of the Pacific is skirted by an alluvial plain of inconsiderable width, and generally very different in character from that on the Atlantic side. In a line along the western side of the table-land there is a continued succession of volcanic mountains, at various distances from the shore, and at various heights, on the declivity towards the Pacific. It seems as if a great crack or fissure had been produced in the earth's surface, along the junction of the mountains and the shore, through which the internal fires had found a vent. There are more than 20 active volcanoes between 10° and 12° N. lat.; some higher than the mountains of the central ridge, and several subject to violent eruptions. Altogether there are 38 in Central America, 17 of which are in Guatemala—a greater number than in any other country, Java excepted.

§ 4. **Proposed Ship Canal between the Atlantic and Pacific.**—In this age of gigantic enterprise it is truly astonishing that there should be any hesitation about joining two oceans by a short canal of only 40 m.; as if modern engineers, aided by the wealth of two of the richest nations in the world, and possessing all the enterprise of the Anglo-Saxon race, could not overcome every difficulty. Instead of the long and stormy voyages round the Cape of Good Hope and Cape Horn, a ship canal joining the Atlantic to the Pacific would open a direct line of communication for all the maritime powers of Europe and the United States, not to the W. coast of the American continent alone, but to China, Australia, and even India, by which the hurricane region would be avoided and the passages made through a comparatively safe and calm sea.

Six different lines across Central America have been proposed as suited for the purpose; but that by the Isthmus of Darien seems to possess advantages over the others, confirming the opinion given more than 50 years ago, and maintained to the last by the greatest of modern travellers and geographers, Humboldt. It possesses the principal requisites for such an undertaking—a short distance of only 40 m. between the tidal limits of rivers flowing into the two oceans, even allowing one third for the possible windings of a canal, and a good harbour at both ends. The line which attracted so much attention a few years ago between the River Savana and Caledonia Bay presents an obstacle in the great height of the mountain ridges near the Atlantic side. But a route farther S., explored by M. de Puydt in 1865, seems to be clear of this obstacle; a depression in the range having been found near the head waters of

the River Tanela, N. of the delta of the Atrato and not far distant from the navigable part of the River Tuyra, which disembogues in the Gulf of San Miguel, where there are high tides, and where docks of any magnitude could be formed.

This line passes near the very country of romance. It was from Caledonia Harbour that Nuñez de Balboa crossed to the South Sea, and that the earliest expedition was sent by the Spaniards to Peru. Here were the gold mines of Tisingal, which gave the name of Costa Rica to the shores of the Pacific, the true El Dorado, to which Sir Walter Raleigh and Sir Francis Drake were sent. The harbour still bears the name of the unfortunate colony from Scotland; and the country in which it is situated, known as the 'Spanish Main,' was celebrated for the lawless but romantic adventures of the Buccaneers. The coast of the Pacific here is rich to exuberance; two crops may be raised in the year; forests of the cocoa nut palm extend for miles; it produces the cacao bean, vanilla, india-rubber, Palo de Vaca, the Tonquin bean, Chiraqui incense, numerous dyewoods, balsams, medicinal plants, and all the usual productions of a tropical climate. But the vegetation is so rank, the high trees so interlaced with creepers, that the light is shut out; the heat is so intense, and rain so frequent, that the climate is exceedingly unhealthy; and although it would be of no consequence to a steamer passing rapidly through 40 m., yet it would be a serious difficulty during the construction, which might, however, be overcome by employing the free labour of negroes, who are accustomed to hot and damp climates. In the mean time the Panama railway conveys goods and passengers to and from the golden lands of California and British Columbia.[1]

§ 5. **The West Indian Islands**, which are separated from both continents by a deep sea, consist of 3 distinct groups; namely, the Lesser Antilles or Caribbean Islands, the Greater Antilles, and the Bahama or Lucay Islands. Some of the *Lesser Antilles* are flat; but their general character is bold, with an insulated peak or a group of mountains in the centre, which slopes to the sea all round, more precipitously on the eastern side, which is exposed to the force of the Atlantic current. Trinidad is the most southerly of a chain of magnificent islands, which, forming a semicircle, enclose the Caribbean Sea, with its convexity facing the E. The range is single as far as Guadaloupe, where it splits into two. Trinidad, Tobago, St. Lucia, and Dominica are particularly mountainous, and their mountains are cut into deep narrow ravines, or gulleys, covered by primeval forests. The

---

[1] Admiral Fitzroy on the Great Isthmus of Central America, in 'Geographical Journal,' vol. xx. M. de Puydt, ibid. vol. xxxviii.

volcanic islands, which are mostly in the undivided part of the chain, have conical peaks bristled with rocks of a still more rugged form; but almost all the islands of the Lesser Antilles have a large portion of excellent vegetable soil in a high state of cultivation. Most of them are surrounded by coral reefs, which render navigation dangerous, and there is little intercourse between these islands and still less with the Greater Antilles, on account of the prevailing winds and currents, which make the return voyage, except by steam, difficult. The Lesser Antilles terminate in the group of the Virgin Islands, which are small and flat, some only a few feet above the sea, and most of them consisting of mere rocks of coral.

The 4 islands which form the group of the *Greater Antilles* are the largest and most important in the archipelago. Porto Rico, Haiti or San Domingo, and Jamaica, separated from the Virgin Islands by a narrow channel, lie in a line parallel to the coast chain of Venezuela, from E. to W.; while Cuba, by a serpentine bend, separates the Caribbean Sea, or Sea of the Antilles, from the Gulf of Mexico. Porto Rico is 110 m. long and 40 broad, with wooded mountains passing through its centre, nearly from E. to W., which furnish abundance of water. There are extensive savannahs in the interior, and very rich soil on the northern coast, but the climate near the sea is unhealthy.

Haiti or *San Domingo,* 400 m. long and from 60 to 160 broad, has a chain of mountains in the centre, extending from E. to W. like all the mountains in the Greater Antilles, the highest point of which is 9000 ft. above the sea. A branch diverges from the main stem to Cape Tiburon, so that Haiti contains a great proportion of high land. The mountains are susceptible of cultivation nearly to the summit, and are clothed with undisturbed tropical forests. The extensive plains are well watered, and the soil, though not deep, is productive.

Jamaica, the most valuable of the British possessions in the West Indies, has an area of 4190 sq. m., of which 110,000 acres are cultivated, chiefly as sugar plantations. The principal chain of the Blue Mountains lies in the centre of the island, from E. to W., with so sharp a crest that in some places it is only 4 yards across. Offsets from it cover all the eastern part of the island. The more elevated ridges are flanked by lower ranges, descending to verdant savannahs. The escarpments are wild, the declivities steep, and mingled with stately forests. The valleys are very narrow, and not more than a twentieth part of the island is level ground. There are many small rivers, and the coast line is 500 m. long, with at least 30 good harbours. The mean summer heat is 80° Fahr., and that of winter is 75°. The plains are often unhealthy, but the air

in the mountains is salubrious; fever has never prevailed at the elevation of 2500 ft.

Cuba, the largest island in the Colombian Archipelago, has an area of 44,669 sq. m. and 200 m. of coast, but is so beset with coral reefs, sandbanks, and rocks that only a third of it is accessible. Its mountains, which attain the height of 8000 ft., occupy the centre, and fill the eastern part of the island in a great longitudinal line. No island in these seas is more important with regard to situation and natural productions; and, although much of the low ground is swampy and unhealthy, there are vast savannahs, and about a seventh part of the island is cultivated.

The *Bahama Islands* are the least valuable and least interesting part of the archipelago. The group consists of about 500 islands, many of them mere rocks, lying E. of Cuba and the coast of Florida. Twelve are larger, and cultivated, producing logwood and mahogany. The most intricate labyrinth of shoals and reefs, chiefly of corals, madrepores, and sand, encircle these islands; some of them rise to the surface, and are adorned with groves of palm trees. Watling's Island, in latitude 24° N., is the first part of the New World on which Columbus landed—the next was Haiti, where his ashes rest.

§ 6. **Geological Notice.**—The Geology of Central America is little known; nevertheless it appears, from the confused mixture of table-lands and mountain chains in all directions, that the subterraneous forces must have acted more partially and irregularly than either in South or North America. In the West Indian Archipelago volcanic action is confined to the smaller islands, which, forming a line in a meridional direction, extend from 12° to 18° N., and may be designated as the Caribbean range; it begins with Granada and ends with St. Eustatius. St. Vincent, St. Lucia, Martinique, a great portion of Guadaloupe, Montserrat, Nevis, and St. Kitts are volcanic; most of them possess craters recently extinct, which have vomited ashes and lava within historical periods; whilst the less elevated of the smaller islands, Tobago, Barbadoes, Deseada, Antigua, Barbuda, and St. Bartholomew's, with the Virgin Islands, and Bahamas, are composed either of calcareous or coral rocks.

CHAPTER XII.

NORTH AMERICA.

§ 1. **General Configuration of the Continent.**—The continent of North America, including Greenland, has an area of more

than 8,000,000 sq. m. It comprises a large central plain, a broad elevated plateau, two great mountain systems, and two long oceanic slopes. The great plain extends N. and S. from the Gulf of Mexico to the Arctic Ocean. It is bounded on the E. by the Appalachian or Alleghany Mountains, and on the W. by the table-lands from which rise the peaks of the Rocky Mountains. 'This broad and elevated belt of table-lands and parallel chains is one of the largest mountain systems of the globe, much exceeding in its solid bulk above the level of the sea even the mighty chain of the South American Andes, being twice as broad and nearly as long.'[1]

Commencing from the S., the *table-land of Anahuac*, or *Mexico*, which, though not the highest, is by far the most extensive plateau on the face of the earth, extends 1600 m. from its S. extremity at the Isthmus of Tehuantepec to the S.W. of New Mexico, a distance equal to that from the N. of Scotland to Gibraltar. From thence it is continued in a series of table-lands and isolated ranges, not absolutely continuous with the Rocky Mountains, but midway between them and the coast ranges, which extend from California to the most northern extremity of the continent. At its S. extremity, where the Mexican table-land is narrow, mountains rise from the isthmus and abut upon it; on the E. the plateau descends so abruptly from a height of 3000 ft. that, seen from the shores of the Mexican Gulf, it looks like a chain of mountains, while on the W. it descends gently to the coast of the Pacific by a series of four longitudinal valleys. On the surface of the plateau groups and ridges of mountains rise; but where it is not traversed by these elevations the table-land is as level as the ocean, so that a carriage road of more than 1000 m. from the city of Mexico northward is over either a dead level or gentle undulations.

The *capital of Mexico*, once the royal residence of Montezuma, must have greatly surpassed the modern city in extent and magnificence, as many of its remains show. It is 7468 ft. above the level of the ocean, and surrounded by four plains, of which Tenochtitlan is the most remarkable, being of elliptical form, 55 m. long, and 35 wide, enclosed by ridges of basalt and porphyritic rocks running from S.S.E. to N.N.W. On the S.E. side, which is the highest, stands the snow shrouded cone of Orizaba (17,337 ft.), with its ever fiery crater, seen like a star in the darkness of the night, which has obtained for it the name of Citlaltepetl—'the Mountain of the Star.' Popocatepetl—'the Smoking Mountain'—the loftiest mountain in Mexico, 17,884 ft. above the ocean, lies farther W., and is in a constant state of eruption, which, with the

[1] Prof. H. D. Rogers.

volcanoes of Iztaccihuatl (15,705 ft.) and Toluca (13,416 ft.), form a magnificent volcanic circuit, in the midst of which Mexico and its lake are situated. The volcanic cone of Tuxtla rises in a group of wooded hills near the shores of the Gulf of Mexico; and on the plains of the Malpays, on the W. slope of the table-land about 100 m. from the Pacific, is the volcanic cone of Jorullo, which rose suddenly, in the night of the 29th of September 1759, to the height of 1700 ft. above the level of the plain, amidst hundreds of little flaming cones which covered the country from 3 to 4 sq. m. The great volcano of Colima stands insulated on the plain of that name, also between the western declivity of the table-land and the Pacific.

Deep cavities called *Barancas* or *Cañons* are a characteristic feature of the table-land of Mexico: they are large rents 2 or 3 m. broad and many more in length, often 1000 ft. deep, with a brook flowing through them. Their sides are precipitous and rugged, with overhanging rocks covered with trees. Vegetation varies with the elevation; consequently the exuberance which adorns the coasts of the gulf vanishes on the high plain, which, although producing much grain and pasture, is often saline, sterile, and treeless, except in some places where oak trees grow to an enormous size.

The *Mexican Table-land* maintains a very great altitude to the N., where the plateau of Sonora forms its continuation, and overhangs the Gulf of California from 25° to 32° N. lat. Near Guanaxuato the breadth is about 100 m. The W. chain is the Sierra Madre, which contains rich silver mines; it goes through Zacatecas and W. of Chihuahua, then it runs due N. under the names of Sierra de Acha and Sierra Verde. The E. chain is that of Cohahuela and Potosi, which lifts itself out of the western edge of the great central plain like a huge colossal wall deeply indented and gashed in its steep flank, with vast mountain buttresses jutting forward into the plateau of the American desert.

§ 2. **The Rocky Mountains.**—In the S. of Colorado, the Rocky Mountain plateau retains the name of the Sierra Madre; and here it has an average elevation of 12,000 ft. and a breadth of 300 m. Elevated valleys of great size and beauty, in which the rivers flowing E. and W. take their rise, occur on both slopes of the Sierra Madre. In Colorado Territory four of these parks exist —the North, Middle, South, and San Luis Parks—each about 9400 sq. m. in extent, elliptical in form, and surrounded by mountains which reach the limit of perpetual snow. The elevation of these parks is from 8000 to 10,000 ft., the highest portion being in lat. 39°, along the N. edge of South Park, from which there is a great decline in both directions. They are separated from each other by vast sweeps of the Cordillera from E. to W. The moun-

tain sides are clothed with pine, spruce, fir, and aspen, and fine grassy meadows abound in the lower grounds.

The fertile plain of Santa Fé and Rio Grande del Norte, 50 m. broad at its northern extremity, is situated in a depression of the Rocky Mountain plateaux. There is a break in the mountain chains at the northern end of the Sierra Verde for 8 m., so that the plain of the table-land, itself 9000 ft. above the level of the sea, becomes the watershed of the Californian Colorado on one hand, and of the rivers which run into the Gulf of Mexico on the other. Through the Passes of this region the railway which unites the two oceans has been carried. The Pass of Kutanie is in 48½° N. lat., so it lies within the British territory, but a railway could only be made to pass through it by tunnels many miles long; whereas the Vermilion Pass, which is a deep gorge N. of the lofty group of mountains that rise 16,000 ft., is only 5000 ft. above the level of the sea, which is 1000 ft. less than any known Pass over the Rocky Mountains, and is 4000 ft. lower than the watershed of the Colorado and the Mexican Gulf mentioned above.

North of this break the Rocky Mountains separate into three chains, and become very complicated. Between the River Arkansas and the N. fork of the Platte there are peaks which rise to 10,000 and 12,000 ft., 'but the Wind River Mountains are the highest of that chain, where Fremont's Peak has an elevation of 13,570 ft. This great range is the axis or central watershed of the whole continent; the head streams of the Missouri flow from its eastern flank, and those of the Columbia and Rio Colorado, which go to the Pacific, from its western.' More to the N., in the eastern or principal chain, and near the sources of the Saskatchewan, are Mount Hooker (15,700 ft.), Mount Brown (16,000 ft.), and Mount Murchison (15,789 ft.). The mountains now decrease in height; N. of the 58th parallel they are only 4000 ft. above the sea, and about 3000 in 62° N. lat.

§ 3. **The Great Western Desert Plateau.**—The table-land of Anahuac is continued to the N. by the plateau of Sonora, in which are many fertile valleys. To it succeeds the Great Western Desert plateau, a wide, elevated desert belt stretching from the Gulf of California to the Arctic Ocean, having a mean elevation of 5000 ft. above the level of the sea, and spreading over 13° of longitude between the parallels of 35° and 45°. It consists of three great regions or basins. The most southerly is the basin of the Colorado at the head of the Gulf of California, a region of mountain ridges and table-lands which slope gently to the west and to the Gulf; this basin has an area of 200,000 sq. m., or nearly as large as France. Except the alluvial flats along the lower course of the Colorado, the country consists of a succession of arid and barren terraced plateaux, through which the main river and its tributaries

have scooped narrow ravines or cañons of prodigious depth. The grand cañon of the Colorado is 500 m. long, and from 2000 to 5000 ft. deep. Thus the streams of the region, instead of flowing near the surface and irrigating the country, are lost in the bowels of the earth, leaving the uplands to everlasting sterility. The second great natural division is the central basin or Great Salt Desert of Utah, having an area of 250,000 sq. m. This is an enclosed continental river basin consisting of vast elevated desert steppes from 4000 to 5000 ft. above the sea, many of these arid plains being covered with incrustations of salt, and divided by mountain ridges trending N. and S. It is a dry, rainless region, because the prevailing winds come from the Atlantic on one side, and the Pacific on the other; the former are deprived of their moisture while blowing over the continent and Rocky Mountains, whereas the vapour brought from the Pacific by the west winds is precipitated on the tops of the lofty coast chains, so that both arrive as dry winds at the desert, which is consequently doomed to perpetual barrenness, at least till some great geological change takes place. The desert has therefore few streams, the Humboldt is the greatest yet known: but it has innumerable lakes, which, having no outlet, are naturally salt because whatever streams fall into them continually bring salt from the soil around; and, as in that latitude the evaporation is very great, the water goes off and the salt remains, and has increased so much in some of the lakes, as e.g. the Great Salt Lake, that it is charged with common salt almost to saturation. That lake, the Utah, and Nicollet lakes are the best known; but there is a long line of them, probably less salt, at the eastern foot of the Sierra Nevada.

In the third natural division the Desert plateau becomes much contracted in width towards the 50th parallel of N. latitude, and extends along the western side of the Rocky Mountains northward through half the continent, sloping gently to the W. and to the Arctic Ocean. It contains the basins of the Frazer and Simpson Rivers, and the affluents of the Oregon or Colombia. 'All these rivers flow to the Pacific through the Cascade range. Still farther to the N.W., beyond the sources of the M'Kenzie River, the long belt is longitudinally drained by the Yukon, which reaches the sea in Norton Sound of Behring Strait.' 'The whole of this long belt of country has an undulating surface of fertile valleys and table-lands, but in the basin of the Oregon high rugged volcanic plains are found. It has a mild climate, many lakes, and feeds some of the greatest rivers.'

§ 4. **The Mountain System of the Pacific.**—The mountain system of the Pacific, which bounds the great Desert zone on the W., maintains a general parallelism to the eastern or proper chain

of the Rocky Mountains, and ranges from the peninsula of California through the whole distance to Alaska Territory. It is a wide, complex, and very elevated chain of mountains, its main central crests and loftiest peaks surpassing those of the Rocky Mountains in altitude. In lower or peninsular California, where it bears the name of Sierra de Lucia, it is a single ridge, but in lat. 35° it divides into two branches trending northwards, namely the Coast Mountains of California and Oregon, and the Sierra Nevada; between these lies the gold producing valley of California. The Coast Mountains run close to the Pacific, W. of the valleys of Sacramento and Wahlahmath, and extend in a broken chain to Vancouver Island; while the Sierra Nevada, the great watershed which insulates the enclosed and elevated plateau of Utah from the golden basin of California, and culminates in Mount Whitney (14,898 ft.), passing the 42nd parallel, is continued in a N.N.E. direction by the Cascade Mountains, the loftiest part of the whole range, on which are situated Mount Pitt and Mount Jefferson in Oregon, and Mount Baker on the borders of British Columbia. It takes its name from the number of rapids and waterfalls that traverse it where it crosses the Frazer and Oregon Rivers. Passing these, it goes N.W. to Alaska Territory, where it curves round and extends W. till it ends in the volcanic peninsula of Aliaska. It contains three peaks, which are 14,500 ft. above the sea, and even more; those of St. Helen's and Mount Regnier are active though rather torpid volcanoes, while Mount Baker, Mount Fairweather, and Mount St. Elias, the highest points of the chain, are all supposed to be occasionally in eruption.

The Pacific slope is a long but comparatively slender belt between the Great Pacific chain and the ocean. In the peninsula of California it is a narrow tract sloping rather steeply to the sea; but N. of the 34th parallel its average breadth is 100 m., and it includes the whole continental slope from the Sierra Nevada to the ocean. It consequently comprises the golden valley of California and the Coast Mountains, of which there are three ridges as far as 42° N. lat. Thence N. to the 60th degree the average width is the same, but increases in breadth from Vancouver Island northwards, and separates again into three mountain belts, of which the Wahlahmath is the most easterly. The slope is much penetrated by great spurs from the Cascade range and the Pacific Alps on the E., and on the W. by estuaries and straits. In fact, the archipelagoes and islands along the coast have the same bold character as the mainland, and may be regarded as the tops of a submarine chain of table-lands and mountains which constitute the most westerly ridge of the maritime chains. The mountains on the coast of the Pacific and the islands are in many places covered with

colossal forests, and many of our beautiful shrubs and plants have been brought from thence; but wide tracts in the S. are sandy deserts.

Vancouver Island has recently risen into much importance on account of its excellent harbours and its deposits of coal. Esquimalt Harbour, in the S.E. of the island, is the best harbour on the N.W. shores of North America. The coal, which is chiefly worked at Nanaimo, is found in seams varying from 2½ to 5 ft. in thickness. It is very valuable and largely exported. The sea board scenery of Vancouver Island is abrupt, with numerous fjordlike harbours, especially on the western coasts, where Alberni, Nootka, Quatsino, and other Sounds extend far inland. The interior is elevated. Mount Arrowsmith reaches a height of 5970 ft., the Albert Edward range has an elevation of from 6000 to 7000 ft., and the Victoria Peak reaches 7484 ft. Throughout its whole length the island is occupied by a backbone of trap, which shows strongly marked features of glacial action. The country is covered with dense forests of pine, oak, willow, alder, cedar, and maple. Tracts of grass land are occasionally met with, and lovely lakes and tarns abound.

CHAPTER XIII.

NORTH AMERICA—*continued.*

§ 1. **The Great Central Plains, or Valley of the Mississippi.**—The great central plain of North America, lying between the Rocky and Alleghany Mountains, and reaching from the Gulf of Mexico to the Arctic Ocean, has an area of 3,245,000 sq. m., which is 245,000 sq. m. more than the central plain of South America, and about half the size of the great plain of the old continent, which is less fertile; for although the whole of America is not more than half the size of the old continent, it contains at least as much productive soil. The plain, 3000 m. long, becomes wider towards the N., and has a low table-land which crosses it from Labrador, and along the sources of the Missouri to the northern verge of the Utah Desert. 'Stretching at right angles to this, the broad Rocky Mountain zone, which forms the watershed of the continent, may be regarded as the crest of a vast undulation of the surface descending from an elevation of from 4000 to 6000 ft. to the level of the sea, with only two intervening swells, those on which the Cordilleras of the Pacific and Alleghanies stand.'

Along the whole eastern side of the Rocky Mountains a high plateau extends from the base of the Cohahuela chain to the far

N., including the table-lands N. of the Great Slave Lake, and E. of the M'Kenzie River. At its southern extremity it is from 4000 to 5000 ft. above the level of the sea; but rises to 6000 between the parallels of 38° and 48°, and maintains a considerable elevation beyond. 'From this height the land descends in slopes, but chiefly in bold terraces, to the lower level of the great plain, a structure peculiarly marked between the River Pecos, and the Black Hills of Missouri, where the plateau descends in two very bold terraces; the upper one, which is from 200 to 300 m. broad, has an altitude of 5000 ft. at the base of the mountains, and at its eastern edge it is 1000 ft. above the second steppe. It is a thirsty desert, without tree or shrub, except along the margins of the scanty streams, and at certain seasons is nearly without vegetation. N. of the Missouri it is more grassy, and in the British territories it has many streams and lakes. The Rio Grande and the M'Kenzie flow along this plateau, the one towards the S., and the other towards the N., while the tributaries of the Missouri and Mississippi, and those of the Saskatchewan and Churchill flow across it. The lower terrace is altogether similar to the upper in the S.; but towards its middle and the northern end it has more vegetation, and on the streams thicker belts of trees. All the rivers from the Arkansas to the Pecos inclusive, descending from the upper steppe or terrace, pass out from between confining precipices often several hundred feet high, through narrow sluices of enormous depth. Along the eastern border of this lower treeless steppe there extends for more than 400 m. a remarkable belt of woodland from 5 to 25 m. wide, called the "Cross Timbers." It separates the fertile and well watered plains of Texas, abounding in verdant prairies and clumps of trees, from the barren naked steppes lying between the Missouri and the Rocky Mountains, which are known as the Great Western American Desert,' and which extend for two degrees into the British territories.

Most of the cultivation on the W. side of the Mississippi is along the Gulf of Mexico and in the adjacent provinces, and is entirely tropical, consisting of sugar cane, cotton, and indigo. At the mouth of the Mississippi there are marshes which cover 35,000 sq. m. bearing a rank vegetation, and its delta is a labyrinth of streams and lakes, with dense brushwood, the very home of the crocodile. Salt rocks and saline grounds occur occasionally in the prairies, as the Grand Saline between the Rivers Arkansas and Neseikelongo, which is often covered 2 or 3 inches deep with salt, like a fall of snow; the wild cattle come in multitudes to these places to lick the salt, of which they are very fond. *Prairies*, so characteristic of the North American continent, lie on both sides of the Lower Mississippi; but they chiefly prevail to the W. of it.

These savannahs are sometimes rolling, but oftener level and interminable as the ocean, covered with long rank grass of tender green, blended with flowers chiefly of the liliaceous kind, which fill the air with their fragrance. In the southern districts, as Lower Texas, they are interspersed with groups of magnolias, tulip, and cotton trees; and in the N.W. with oak and black walnut. These are rare occurrences, for the prairies may be traversed for many days without meeting with a shrub, except on the banks of the streams, which are beautifully fringed with myrtles, azaleas, kalmias, andromedas, and rhododendrons. On the wide plains the only objects to be seen are countless herds of wild horses, bisons, and deer. The country assumes a more severe aspect in higher latitudes. It is still capable of producing rye and barley in the territories of the Assiniboine Indians, and round Lake Winnipeg there are great forests; a low vegetation with grass follows; and towards the Arctic Ocean the land is barren and covered with numberless lakes and large streams sunk into narrow valleys which flow into that icy sea.

East of the Mississippi there is a magnificently undulating country, extending 1000 m. from S. to N. between that great river and the Alleghany Mountains, mostly covered with trees. Pine barrens, stretching far into the interior, occupy the whole coast of the Gulf of Mexico eastward from Pearl River through Alabama and a great part of Florida. These vast monotonous tracts of sand covered with forests of gigantic pine trees are as peculiarly a distinctive feature of the North American continent as the prairies, and are not confined to this part of the United States; they occur to a great extent in North Carolina, Virginia, and elsewhere. Tennessee and Kentucky, though much cleared, possess large woodlands; 'almost the whole country between the western slopes of the Appalachian Mountains, and the Mississippi, the Wabash, and Lake Michigan, was originally clothed with forest, and much of it still remains.' The Ohio flows for hundreds of miles among magnificent trees with an undergrowth of azaleas, rhododendrons, and other beautiful shrubs, matted together by creeping plants. There the American forests appear in all their glory; the gigantic deciduous cypress, and the tall tulip tree overtopping the forest by half its height, a variety of noble oaks, black walnuts, American plane, hickory, sugar maple, and the liriodendrons, the most splendid of the magnolia tribe, the pride of the forest.

The Illinois waters a country of 'prairies.'[1] Five new States

---

[1] *Prairie* (Fr. *prairie* = 'a meadow'), an extensive tract of level or rolling land covered with coarse grass and destitute of trees.

occupy a territory of 280,000 sq. m. round the great lakes, which embraces 180,000,000 acres of excellent land. These States lie between the lakes and the Ohio, and they reach from the United States to the Upper Mississippi, a country twice as large as France, and 6 times the size of England; but almost the whole of this noble plain of North America is unrivalled in every natural advantage.

The quantity of water in the N.E. part of the central plain greatly preponderates over that of the land; the 5 principal lakes —Huron, Superior, Michigan, Erie, and Ontario—cover an area equal to Great Britain, without reckoning innumerable smaller lakes and rivers.

§ 2. **British North America**, including the shores of the Polar Ocean and the recently established colony of British Columbia, comprises an area of 3,513,325 sq. m., and a population estimated in 1875 at 4,000,000, exclusive of about 85,000 Indians. Though large tracts on the Arctic Ocean are uninhabitable, there is no perpetual snow over a wide extent of them, and severe winters do not prevent the growth of the cerealia and deciduous trees, for whenever a summer heat of 56° lasts for 100 or 120 days, wheat may be profitably cultivated: the limit seems to be the 65th parallel of latitude, so that even the northern parts are not so desolate as is generally supposed. Canada, by far the most valuable of the British Colonies, has an area of 301,000 sq. m. No country in the world surpasses Canada in the produce of wheat. Every plant that requires a hot summer and can endure a cold winter thrives there. Whole districts of many square miles are of alluvial soil, from 30 to 80 ft. deep, which in some places is so rich as to bear good crops for several successive years without manure, and there are many continuous tracts, especially along the rivers, too rich for wheat.

Although there is much productive soil in Lower Canada or Quebec, yet the largest and finest tracts of land are in Upper, now called Ontario, or Western Canada, which is a plain of 20,000 sq. m., of great fertility, mostly covered with noble forests, which show the strength of the soil. The trees are chiefly deciduous, as maple, beech, oak, basswood, elm, hickory, walnut, chestnut, cherry, birch, cedar, and pine.

More to the N. deciduous trees become scarcer, and pine forests of great variety prevail. Of the whole 114 species of known pines, 21 are natives of Canada, or the Hudson Bay Territory. The balm of Gilead fir, the hemlock, and black spruce are common; the latter is also found in Nova Scotia. The Pinus alba, or white spruce, is one of the most beautiful of the Canadian trees; it grows to the height of 140 ft., with branches feathering down to the

ground and leaves of a sea green hue; but the Weymouth pine is the largest in the Canadian woods, and grows in most of the districts E. of the Rocky Mountains. It frequently grows to the height of 200 ft., but in the Canadian forests it is like a bare spar with a tufted crown, casting a deep gloom below.

These noble Canadian forests are rapidly falling under the axe: already the largest trees on the rivers have been cut down, the smaller ones only being left, because the great river system of this country affords the means of transporting the timber to the sea by rafts. In 1874 the value of the timber exported amounted to nearly 5,558,285*l.* sterling.

§ 3. **Hudson Bay Territory.**—That magnificent region, extending from the Canadas to the Pacific Ocean, was for more than a century only known to the Hudson Bay Company, who had many settlements scattered over it for the capture of fur bearing animals, which are so valuable and numerous that they employed 100,000 Indians in the chase. Since the discovery of the gold producing district has led to the establishment of the Colony of British Columbia, W. of the Rocky Mountains, surveys have been made for a Canadian Pacific railway which will connect the two oceans. The country between Lake Superior and the Red River settlement of the Hudson Bay Company consists of chains of rivers and lakes of the most romantic scenery; that on Sturgeon Lake is said to be of the highest order; and the scenery among the islands of the Lake of the Woods is singularly picturesque, consisting of every variety of bare precipitous rock, abrupt timbered hills, gently wooded slopes, and open grassy plains; and so abundant are the flowers on the banks of these secluded lakes that they look like a neglected garden. In fact, the great lakes of the Winnipeg Basin, embracing an area of water of 13,000 sq. m., are bounded on the W. by abrupt and precipitous escarpments, which bear the marks of having been an ancient coast line when the ocean was relatively 1600 ft. above its present level. On their western flanks these ranges descend in steps and gentle slopes to the fertile valleys of the Assiniboine and Swan Rivers, and are densely wooded with valuable timber trees.

Captain Palliser, in his exploring expedition, found that the southern branch of the Saskatchewan flows through a sterile country that seems to be part of the great American Desert, but he discovered a large navigable river equal to the Missouri in size and volume. It issues from the chain of the Qu'appelle Lakes and joins the Saskatchewan, which, with its tributaries, falls into Lake Winnipeg after having watered the Buffalo prairies. It is estimated that the country drained by the Saskatchewan and the Red

River contains 155,000 sq. m. Of this land about 80,000 sq. m., lying S. of the elbow of the Saskatchewan and the Qu'appelle River, would be adapted for grazing. At the base of the Rocky Mountains there is a strip of fertile territory, and on the N. branch of the Saskatchewan there are about 65,000 sq. m., one third of which is fit for immediate cultivation. Though the winter is severe, the number of buffaloes that live on these grounds shows that they are perfectly suited for settlements.

§ 4. **The Rocky Mountains.**—It is singular that the lowest Passes in the Rocky Mountains should be in the highest part of the chain. Captain Palliser and his party discovered three that might be available for carrying a railway across, all of which are on British ground. The Vermilion Pass is described as a deep gorge between high peaks, and only 4947 ft. above the level of the sea; the Kananaski Pass is through a wide sloping valley, with a comparatively easy descent to the W., which by a tunnel might be reduced to the absolute height of 4600 ft. The third is the Kutanie Pass. The Yellow Head Pass, leading from the Athabasca to the Upper Frazer, has been explored by Dr. Rae. It is N. of the others, in latitude 52° 54′ N., and crosses the mountains by a series of easy gradients, its greatest altitude being 3760 ft. This Pass leads into the valley of the Thomson, a tributary of the Frazer. The valleys of the Thomson and Frazer Rivers are distinguished by a series of raised terraces on a grand scale, which have been traced for 100 m. along the banks of the Thomson and 200 m. along those of the Frazer. These are all perfectly uniform, and correspond on the opposite sides of the valleys. The lower valley of the Frazer is a rugged defile, mountain succeeding mountain between Yale and Lytton, 'bluff after bluff of solid perpendicular granite, intermingled with steep slides of rolling rock, washed by a deep impetuous stream, and 1500 to 2000 ft. high.' It is of extreme importance to establish a communication between British Columbia and the Red River settlement, not only in consequence of the fertility of the latter, but because it lies in the direct line of an interoceanic railway.

The *Rocky Mountains* proper may be considered as only the eastern flank of an immense tract of mountainous country. This attains its greatest height where the western flank—the Cascade range—runs like a wall along the coast, only broken by gorges or nicks, through which the Columbia and Frazer Rivers flow into the Pacific. In British Columbia the Rocky Mountains and the Cascade range approach so close to each other that they may be considered to form one vast chain. Farther N. they enclose between them an elevated plateau of rolling country 100 m. broad. The Rocky Mountains here form a triple range, averaging from 150 to

160 m. wide, the main crest, which is the most easterly, rising abruptly from an elevated plain to a height of 16,000 ft., the middle and western crests being respectively 12,000, and from 4000 to 8000 ft. high. The *Cascade range* runs at a distance of from 20 to 25 m. from the coast far northwards into the Territory of Alaska. Its average width N. of the Frazer River is 110 m., and it forms a sea of mountains, some of its peaks exceeding 10,000 ft. in height, and extending inland till its spurs mingle with those of the Rocky Mountain range. The western slopes of all the mountains are thickly wooded. In the Cascade range there are some fine glaciers, and the coast line penetrates by numerous openings, such as Bute Inlet, far up into the mountains. The scenery is like that of the Norwegian fjords.

The middle and western crests of the Rocky Mountains are gradually depressed N. of Cariboo, and this depression forms a large tract of level and fertile country on each side of the Upper Frazer. The gold region of Cariboo lies in the elbow formed by the Upper waters of the Frazer, and is bounded on the S. by the Quesnelle River. Every creek in the hills contains gold, and auriferous deposits have been traced throughout the whole length of British Columbia in the valleys of the Frazer and its tributaries. Of the interior of the N.W. portion of North America, little is at present known. The seaward slopes of the range, in which Mounts St. Elias (14,970 ft.) and Fairweather (14,708 ft.) rear their mighty crests, are clothed with fine forests, chiefly of pine. Back from these mountains an undulating region extends to the great Yukon River, one of the ranges, the *Ulnluk Mountains*, attaining an altitude of 3000 ft., and forming conspicuous landmarks in a country which is comparatively level. These mountains extend from N. to S. for about 100 m.

§ 5. **The Alleghanies.**—The Alleghany or Appalachian Mountains, which constitute a second and subordinate system of North American mountains, separate the great central plain from that which lies along the Atlantic Ocean. They stretch towards the S.W. from Cape Gaspe, on the Gulf of St. Lawrence, to Alabama, a distance of 1300 m. The system comprises three sections, each of which has its own well marked peculiarity of structure; viz. the *Northern*, which extends from Cape Gaspe to the Hudson; the *Central*, stretching from the Hudson to the New River; and the *Southern*, from the New River to the S.W. extremity. The *Northern* section embraces the Adirondacks, the Green Mountains, and the White Mountains; the *Middle* division comprises the Blue Ridge, the Alleghanies proper, and several minor ranges; the *Southern*, the Smoky, and the Unaka Mountains. The culminating point of the whole system, the *Black Dome*, or

Clingmann Peak (6707 ft.), is in the southern section. The parallelism of the ridges, and the uniform level of their summits, are the characteristics of this chain, which is lower and less wild than the Rocky Mountains. The uniformity of outline in the southern and middle parts of the chain is very remarkable, and results from their peculiar structure.[1] These mountains have no central axis, but consist of a series of convex and concave flexures, forming alternate hills and longitudinal valleys, running nearly parallel throughout their length, and cut transversely by the rivers that flow to the Atlantic on the one hand, and to the Mississippi on the other. The watershed nearly follows the windings of the coast from the point of Florida to the N.W. extremity of the State of Maine.

The Appalachian Mountains are noted for their picturesque and peaceful scenery; they are generally clothed with a luxuriant vegetation, and their western slope is considered one of the finest countries in the United States. To the S. they maintain a distance of 200 m. from the Atlantic, but approach the coast in the S.E. part of the State of New York, from whence their general course is northerly to the banks of the St. Lawrence. But the Blue Mountains, which form the most easterly ridge, are continued in the double range of the Green Mountains to Gaspe Point in the Gulf of St. Lawrence. They fill the Canadas, Maine, New Brunswick, and Nova Scotia with branches as high as the mean elevation of the principal chain, and extend even to the dreary regions of Baffin Bay. The chief Canadian offsets are parallel to the St. Lawrence. The Mealy Mountains, on the E. coast of Labrador, extend from Cape Charles to Sandwich Bay. They rise to a height of 1484 ft. above the sea level, and are wooded nearly to their summits. With the Wotchish Mountains, and the elevated land N. of the St. Lawrence, these mountains have received the name of the Laurentian range. Little is known of the high lands within the Arctic circle, except that they have a general direction from S.E. to N.W.

§ 6. **Decrease of Vegetation towards the Arctic Region.** —The country between Hudson Bay, the mouth of the Churchill River, and that of the Mackenzie, is also an almost unknown region; on the E. it descends steeply to the coast, but the western part, known as the Barren Ground, is low and destitute of wood, except on the banks of the streams. The whole is covered with low precipitous hills. Not only the deep forest, but vegetation in general, diminishes as the latitude increases, till on the Arctic shores the soil becomes incapable of culture, and the majestic

[1] Lyell's 'Travels in North America.'

forest is superseded by the Arctic birch, which creeps on the ground. Many of the islands along the N.E. coasts, though little favoured by nature, produce flax and timber; and Newfoundland, with an area of 40,200 sq. m., maintains a population of 146,536 souls chiefly by its fisheries: it is nearer to Britain than any part of America—the distance from the port of St. John to the harbour of Valentia in Ireland being only 1870 m.

§ 7. **The Atlantic Plain.**—The long and comparatively narrow plain which lies between the Appalachian Mountains and the Atlantic extends from the Gulf of Mexico to the E. coast of Massachusetts. At its S. extremity it joins the plains of the Mississippi, and gradually becomes narrower in its northern course to New England, where it merely includes the coast line and islands. It is divided throughout its length by a line of bluffs from 200 to 300 ft. high, which commences in Alabama and ends on the coast of Massachusetts. This declivity is the eastern edge of the terrace known as the Atlantic Slope, which rises above the Maritime Plain, and undulates westward to the foot of the Blue Mountains, the most eastern ridge of the Appalachian chain. It is narrow at its extremities in Alabama and New York, but in Virginia and the Carolinas it is 200 m. wide. The surface of the slope is of great uniformity; ridges of hills and long valleys run along it parallel to the mountains, close to which it is 600 ft. high. It is rich in soil and cultivation, and affords an immense water power in the streams and rivers flowing from the mountains across it, which are precipitated over its rocky edge to the plain on the E. More than 23 rivers of considerable size fall in cascades down this ledge between New York and the Mississippi, affording scenes of great beauty.[1]

Both land and water assume a new aspect on the Atlantic plain. The rivers, after dashing over the rocky barrier, run in tranquil streams to the ocean; and the plain itself is a monotonous level, not more than 100 ft. above the surface of the sea. Along the coast it is scooped into valleys and ravines, with innumerable creeks.

The greater part of the magnificent countries E. of the Alleghanies is in a high state of cultivation and commercial prosperity,

---

[1] The author is indebted to the article on the 'Physical Features of North America,' in the last edition of Keith Johnston's 'Physical Atlas,' by Prof. H. D. Rogers, to the 'Travels' of Sir Charles Lyell, to Palliser's and Waddington's papers in the 'Transactions of the Geographical Society,' to Mr. F. Whymper's 'Alaska,' and to the 'Quarterly Review' for January 1, 1861, for the greater part of her information on the Physical Geography and Geology of that portion of the New World.

with natural advantages not surpassed in any country. Nature, however, still maintains her sway in some parts, especially where pine barrens and swamps prevail. The territory of the United States covers an area of 3,603,884 sq. m., of which by far the greater part is fertile, and capable of producing everything that is useful to man. The climate is generally healthy, the soil abundant in mineral treasures, and it possesses every advantage from navigable rivers and excellent harbours. Anglo Saxon civilisation is now firmly established on the shores of the Pacific, and the tide of white men is continually and irresistibly pressing onwards to the ultimate extinction of the original proprietors of the soil—a melancholy but not a solitary instance of the rapid extinction of a whole race.

§ 8. **Geological Notice.**—The most striking feature in the geology of North America is the enormous development of the Devonian and Carboniferous strata to the E., and the still more extensive development of the Cretaceous and Tertiary formations to the W. The latter stretch from the S. termination of the Appalachian Hills in Georgia and Alabama, W. to the table-land of Mexico; N.W. to the E. foot of the Sierra Nevada, to California, and the Cascade chain of Oregon; and N. by the broad plain of the Missouri to an undefined limit in the desert steppes that lie beyond that river and E. of the Rocky Mountains. The portions of this enormous area that are Tertiary and alluvial are Florida, a large tract at the mouth of the Mississippi, and the whole coast of the Gulf of Mexico; and to the W., the elevated Salt Desert tablelands from the Gulf of California, through Utah, to their farthest extremity. The peninsular chain of California, and the Sierra Nevada rise out of these strata; but the Rocky Mountains rise through the Cretaceous plain. The Californian chain, the Sierra Nevada, and generally the coast chains are Metamorphic, the storehouse of mineral riches. The gold formation, which seems to be inexhaustible, and which probably extends through Alaska Territory, has given rise not only to the settlement of California, but to British Columbia, and is no doubt destined in the course of time to spread indefinitely over the rich prairies E. of the Rocky Mountains. These Metamorphic coast chains are mixed with Crystalline granite and Volcanic rocks of all ages. The latter are greatly developed at the N. termination of the Utah desert, and all along the Pacific coast. The plateau of Sonora consists of Palæozoic with Volcanic and Trappean rocks, and occasionally Crystalline strata. The Rocky Mountains seem to have the same structure, with the addition of extensive tracts of Carboniferous Limestone.

The geology of the E. part of the continent is of a very

different character. Throughout the whole of the United States and the British provinces of the Atlantic coast and the Atlantic plain westward to the Missouri River, and from the end of the Appalachian chain in the Alabama and the River Washita in Northern Texas to the Territory of Hudson Bay, an area equal to half the breadth of the continent in these latitudes, there is scarcely any strata of later formation than the upper Coal measures. The Devonian and Carboniferous strata prevail from the great lakes to about 36° N. lat., and from the Atlantic Slope to the 97th meridian. They are enormously developed in depth as well as in extent, for the Devonian and Carboniferous strata together are a mile and a half thick in the State of New York, where there is no coal; but it is three times as much in Pennsylvania, and the quantity of coal in the United States is sufficient to supply the whole world for ages, and in many places lies quite on the surface. The Appalachian chain consists of the older Palæozoic strata to the W.; and to the E. there is a wide belt of Metamorphic rocks combined with Crystalline; and along the Atlantic coast the formations are Tertiary and alluvial.

Long lines and patches of the lower Palæozoic rocks are found in Vermont, and among the great lakes; but a very wide and extensive development of Crystalline rocks occupies Vermont, Nova Scotia, where gold has been found, but more especially Newfoundland, and extends along the northern side of the Gulf of St. Lawrence, occupies Lower and Upper Canada, the country of Minnesota, and from thence stretches to the N.W. in a very broad belt to the E. of Lake Winnipeg. A great deal of granite protrudes through this formation, especially in Newfoundland. All the most northern part of the continent is of Silurian and Cambrian strata.

The geological outline of the United States, Canada, and the country round the Polar Ocean, though highly interesting in itself, becomes infinitely more so when viewed in connexion with that of Northern and Middle Europe. A remarkable analogy exists in the structure of the land on each side of the North Atlantic basin. The extensive formation of Crystalline rocks interspersed with granite, which has just been mentioned, ranges also through Scandinavia, Finland, and Lapland. In the latter countries, and in the more northern parts of America, Sir Charles Lyell observed that the Fossiliferous rocks belong either to the most ancient or to the newest formations; to the Silurian strata, or to such as contain shells of recent species only, no intermediate formation appearing through immense regions. Palæozoic strata extend for 2000 m. in the middle and high latitudes of North America; they occupy a tract nearly as great between the most westerly headlands of

Norway and those that separate the White Sea from the Polar Ocean. Sir Roderick Murchison traced them through Central and Eastern Europe, and the Ural Mountains, even to Siberia; Messrs. Abich and Tchihatcheff through the Caucasus and Altaï. They have been seen by Messrs Pentland and D'Orbigny to constitute some of the most elevated pinnacles of the Bolivian Andes; and Colonel Strachey has discovered them at a great elevation in the Himalayas, where they form the summits of the gigantic Jumnotri, and include fossils analogous to those found in the Ural and the Andes. Throughout these vast regions, both in America and in the old continent, the Silurian strata are followed in ascending order by the Devonian and Carboniferous formations, which are of such enormous extent in the United States, and which reappear in New Brunswick and Newfoundland, and traces of them may be found in the islands of the Polar Ocean, on the E. coast of Greenland, and even in Spitzbergen. A vast Carboniferous basin exists in Belgium above the Silurian strata; two or three of less importance in France; and a great portion of Britain is perfectly similar in structure to North America. The Silurian rocks in many instances are the same, and the coal fields of New England are precisely similar to those in Wales, 3000 m. off.

In all the more northern countries that have been mentioned, so very distant from one another, the general range of the rocks is from N.E. to S.W.; and in Northern Europe, the British Isles, and North America, great lakes are formed along the junction of the strata, the whole analogy affording a proof of the wide diffusion of the same geological conditions in the northern regions at a very remote period. At a later time those erratic blocks which are now scattered over the higher latitudes of both continents were most likely brought from the N. by icebergs, while the land was still covered by the deep, or by glacial movement over the land. Volcanic agency has not been wanting to complete the analogy. The Silurian and overlying strata have been pierced in numerous places by Trappean rocks on both continents, and they appear also in the islands of the North Atlantic and Polar Seas.

§ 9. **Fossil Mammalia.**—From the similar nature of the coast, and the identity of the fossil mammalia, on each side of Behring Strait, it is more than probable that the two continents were united, even since the sea was inhabited by the existing species of animals. Some of the gigantic quadrupeds of the old continent are supposed to have crossed either over the land or over the ice to America, to have wandered S. through the longitudinal valleys of the Rocky Mountains, Mexico, and Central America and to have spread over the large plains of both continents even to

their utmost extremity.[1] An extinct species of horse, the mastodon, allied to the elephant, three gigantic edentata and a hollow horned ruminating animal roamed over the prairies of North America, certainly since the sea was peopled by its present inhabitants, probably even since the existence of the Indians. The skeletons of these creatures are found in great numbers in the saline marshes on the prairies, called *Licks*, which are still the resort of the existing races.[2]

§ 10. **Mean Height of Continents.**—The average height of the continents above the level of the sea is the mean between the height of all the high lands and all the low. Humboldt, by whom the computation was effected, found that the table-lands with their slopes, on account of their vast extent and mass, have a much greater influence upon the result than mountain chains. For example, if the ranges of the Pyrenees[3] were pulverised, and strewed equally over the whole of Europe, they would only raise the soil 6 ft.; the Alps, which occupy an area four times as great as that on which the Pyrenees stand, would only raise it 22 ft.; whereas the compact plateau of the Spanish Peninsula, which has only 2298 ft. of mean height, would elevate the soil of Europe 91 ft.; so that the table-land of the Spanish Peninsula would produce an effect nearly five times as great as the whole system of the Alps.[4]

A great extent of low land necessarily compensates for the high—at least it diminishes its effect. The mean elevation of France is 1292 ft., while the mean height of the whole European continent, of 1,720,000 sq. m., is only 974 ft.[5]

The great table-land of Eastern Asia, with its colossal moun-

---

[1] Sir John Richardson on the Fauna of the High Latitudes of North America.

[2] Lyell's 'Travels in North America.'

[3] A chain of mountains is assumed to be a three sided horizontal prism whose height is the mean elevation of the chain, and the base the mean length and breadth of the same, or the area on which the chain stands, and thus its mass may be computed approximately. It is evident that a table-land must have a greater effect on the mean height of a continent than a chain of mountains, for, supposing both to be of the same base and altitude, one would be exactly double the other; and even if the mountains be the higher of the two, their upper part contain much less solid matter than their lower on account of the interva and deep valleys between the peaks.

[4] According to M. Carpentier, the area of the base of the Pyrenees is 1720 sq. m. As the mean elevation of the Passes gives the mean height of the mountains, Baron Humboldt estimated from the height of 23 Passes over the Pyrenees that the mean crest of that chain is 7990 ft. high, which is 300 ft. higher than the mean height of the Alps, though the peaks in the Alps have a greater elevation than those of the Pyrenees in the ratio of $1\frac{4}{10}$ to 1.

[5] 'Geographical Magazine,' June 1, 1875, p. 186.

tain chains, has a much less effect on the mean height of Asia than might have been expected on account of the depression round the Caspian Sea; and still more from the very low level and the enormous extent of Siberia which is as large as all Europe. The intumescences in these vast plains are insignificant in comparison with their vast area, for Tobolsk is only 378 ft. above the level of the sea; and even on the Upper Angora, at a point nearer the Indian than the Arctic Sea, the elevation is only 830 ft., and the third part of Asia has a mean height of only 255 ft. The effect of the Desert of Gobi is diminished by a vast hollow 2560 ft. deep, the dry basin of an ancient sea of considerable extent near Erga, so that this great desert has a mean height of but 4000 ft., and consequently it only raises the general level of the Asiatic continent 128 ft., though it is twice as large as Germany. The table-land of Tibet, the mean elevation of which is about 14,500 ft., together with the chains of the Himalaya and Kuen-lun which enclose it, only produces an effect of 440 ft. On the whole, the mean level of Asia above the sea is 1150 ft.[1]

Notwithstanding the height and length of the Andes, their mass has little effect on the continent of South America on account of the extent of the eastern plains, which are one third larger than Europe. For if these mountains were reduced to powder and strewn equally over them, it would not raise them above 518 ft.; but when the minor mountain systems and the table-land of Brazil are added to the Andes, the mean height of the whole of South America is 1130 ft. North America, the mountain chains of which are far inferior to those in the southern part of the continent, has its mean elevation increased by the table-land of Mexico, so that it has 750 ft. of mean height.

The mean elevation of the whole of the New World is 930 ft. above the level of the sea, and that of the continental masses of Europe and Asia 1010 ft. Thus it appears that the internal action in ancient times has been most powerful under Asia, somewhat less under South America, considerably less under North America, and least of all under Europe.

With respect to the bed, temperature, and distribution of the fauna of the ocean, it is only recently that enough has been accurately ascertained to warrant any trustworthy inferences. Thanks, however,

[1] The Russian Academicians MM. Fuss and Bunge found by barometrical measurement the mean height of that part of the Eastern Asiatic table-land lying between Lake Baikal and the Great Wall of China to be only about 6960 ft. The smallness of this mean is owing to hollows in the table-land, especially in the Desert of Gobi. See also 'Mongolia' by Col Prejevalsky, vol. i. p. 16.

to the systematic scientific explorations of the 'Lightning,' 'Porcupine,' and 'Shearwater' (in 1869, 1870, and 1871), and of the 'Challenger' (1872–1876), our knowledge is now upon a totally different footing. During her cruise the 'Challenger' crossed the Atlantic five times, establishing along her course of upwards of 20,000 m., 150 observing stations. She traversed the Pacific with a course of 20,000 m. and established 100 stations. She explored the seas about Australia, New Zealand, the Malay Archipelago, and S.E. China, running a course of 17,000 m., and setting up 66 observing stations; and she spent nearly a month among the southern ice, and dipped within the Antarctic Circle as far as, under her circumstances, she prudently could. Her scientific corps collected data which show that the vast region covered by sea is to a certain degree comparable with the land; that it has its hills, valleys, and great undulating plains; that it has various soils, its own climates, and its peculiar races of inhabitants, which depend, like the inhabitants of the rest of the world, upon the conditions of climate and on the nature of the soil for their distribution. They found reasons for inferring that the *mean depth* of the ocean is probably about 2500 fathoms: and they observed with regard to the *temperature* of large oceans, that it gradually falls from the surface to the bottom; that 45° is a very general temperature for a depth of 500 fathoms, and that from this point downwards the temperature slowly but gradually descends to near the freezing point, or sometimes even below it; and they have concluded that, as a rule, the temperature at the bottom of the sea is very uniform and very low. The explorers have proved by observation that the deep sea is no barren waste of waters, but that, on the contrary, a fauna very remarkably constituted and comparatively rich, is universally distributed, even to the greatest depths.[1]

CHAPTER XIV.

ISLANDS OF THE PACIFIC AND INDIAN OCEANS.

§ 1. **The continent of Australia** being nearly destitute of large navigable rivers, it was concluded that no very high land existed in its interior, even before it had been explored. The absolutely unknown districts of the country are now small when compared with the vast areas which have been to a greater or

---

[1] See Sir C. Wyville Thomson's 'Address' to the British Association at Glasgow, September 11, 1876.

less degree completely explored. It has been determined that the central regions are low, and that much of the drainage finds its way into the lakes Eyre and Alexandria. It is 2400 m. from E. to W., and 1971 from N. to S., and is divided into two unequal parts by the Tropic of Capricorn; and so has both a temperate and a tropical climate. New Guinea, separated from Australia by Torres Strait, and traversed by the same chain of mountains with Australia and Tasmania, is so similar in its productions that it may be regarded as a detached member of the adjacent continent.

The coasts of Australia, about 8000 m. in length, are indented by large bays, and by harbours that might give shelter to all the navies in Europe. The most distinguishing feature of the E. side, which is occupied by the British colonies of Queensland and New South Wales, is its coast system of mountains which constitute a regular cordillera of about 150 m. broad, extending from the S. to the N. 1700 m. in length, with a mean elevation of 1500 ft. above the sea. The distance of the chain from the sea in New South Wales is from 50 to 100 m., but at the 32nd parallel it recedes to 150 m., yet soon returns, and forms the wild group of the Coricudgy Peaks, from whence, under the names of the Blue Mountains and Australian Alps, its highest part, it proceeds in a general S. and S.W. direction to the land's end.

Mount Kosciusko (7176 ft.), the loftiest of the Australian Alps, is so situated that the view from its snowy and craggy tops sweeps over an area of 7000 sq. m. The rugged and savage character of these mountains far exceeds what might be expected from their height: in places, it is true, their tops are rounded and covered with forests; but by far the greater part of the chain, though wooded along the flanks, is crowned by naked needles, serrated peaks, and flat crests of granite or porphyry, mingled with patches of snow. The spurs give a terrific character to these mountains, and in many places render them altogether inaccessible both in New South Wales and Tasmania. These shoot out right and left from the axis of the main range, equal to it in height, and separated from it, and from each other, by dark and almost subterraneous gullies, iron bound by impracticable precipices, with streams flowing through them in black silent eddies or foaming torrents. The intricate character of these ravines, the danger of descending into them, and the difficulty of getting out again, for a long time rendered this mountain chain, in New South Wales at least, almost an impassable barrier between the coast country and the interior.[1]

[1] 'Memoirs of Count Strzelecki.'

In New South Wales the country slopes westward from these mountains towards a flat, low, unbroken plain. On the E., dark verdant, round topped hills and ridges are promiscuously grouped together, leading to a richly wooded undulating country which gradually descends to the coast and forms the valuable lands of the British colony. Visited by Cook[1] in the year 1770, it was not colonised till 1788, and since that time the Australian colonies have risen with unprecedented rapidity: they contain upwards of 1,800,000 inhabitants; the *exports* in 1873 amounted to 36,407,428*l.*; the *imports* to 35,738,295*l.* The colonies administer their own laws, and the principal towns have their houses of representatives. On the Australian continent there are 5 colonies: viz. Queensland on the E., which includes the whole of the N.E. portion; New South Wales, the oldest settlement, S. of Queensland and N. of the Murray River; and Victoria, which occupies the S.E. corner, S. of the Murray, and E. of 141° E. longitude. South Australia embraces all the territory N. of 3° S. lat., and stretches from 129° to 141° E. longitude. Western Australia includes all that portion of New Holland situated W. of 129° E. long.; but only the S.W. part of it is occupied.

Sydney, the capital of New South Wales (pop. 134,755), is a large handsome city. It has various public buildings in good architectural taste, and contains the luxuries and comforts of European society. It lies on the S. shore of Port Jackson, and the approach to it is very pretty. *Melbourne*, the capital of Victoria, the largest and most important city of Australia, lies on the Yarra Yarra, which flows into Hobson's Bay, the most northern arm of Port Phillip, and which is only navigable for small vessels. The town was only founded in 1837; but its present population is 200,000, so rapidly have the gold fields attracted emigrants. It contains many handsome public buildings, and its botanic garden is of considerable importance. It has five or six museums, a large public library of upwards of 70,000 volumes, several hospitals, and a university. The town is situated 2½ m. by land from Hobson's Bay, but 7 or 8 m. by the river. Its port is Williamstown on Hobson's Bay, and on the shores of Port Phillip are Brighton, St. Kilda, and other places, which are almost suburbs to Melbourne. There are many other flourishing and populous towns in New South Wales, Victoria, and Queensland; the improved navigation of the Murray has tended greatly to the

---

[1] Torres sailed through the strait which is named after him in 1606. The Dutch ship 'Endraght,' commanded by Dirk Hartog, sailed along the W. coast from 26° 30′ to 23° S. lat. in 1616. Other Dutch vessels explored parts of the N. and S. coasts in 1618 and 1627

prosperity of this part of the continent. From Spencer Gulf, which has three excellent harbours, one of which could contain the whole British navy, that river has been navigated for 2650 m., and it is estimated that 1150 m. more may be added by the improved navigation of three of its tributaries. In consequence of this increased water carriage many new towns have been built. There is much grass land in this district; and if artesian wells be dug in the vast salt bush countries still unoccupied, a prodigious increase of cattle and sheep might be maintained. This internal navigation extends to the different auriferous districts; and as 1300 m. of it lies within the territory of New South Wales, it unites the traffic and mutual interests of three of our greatest Australian colonies.

In the southern half of the continent the mountain and hilly ranges are called the *Dividing Range,* and include the Australian Alps in the E., the Pyrenees, and Grampians in the W.—in Victoria; the Flinders Range in South Australia; and the Darling Range in Western Australia. Strong W., generally S.W., or sometimes N.W. winds prevail over the S. part of the continent during the greater part of the year, and, owing to precipitation of rain from these up to 30° S. lat., there are fertile tracts on the seaward sides of the mountains; but these winds in passing over the mountain tops are drained of their moisture, so that on their inland sides barren wastes prevail. W. of the Darling Range, which is from 3000 to 4000 ft. high, there is a grassy and wooded country which is comparatively fertile.

Extended explorations of the interior of Australia produced results which were somewhat unexpected. Sturt's journey in 1844 had led him to a stony desert in lat. 24° S., long. 138° E., and that of Gregory, from the N.W., to a sandy desert in lat. 21° S., long. 128° E. Mr. Eyre's adventurous journey along the shores of the great Australian Bight in the S. had shown them to be destitute of fresh water. It was therefore supposed that a great sandy desert lay in the interior. But explorations of the N. coast showed that many rivers, such as the Albert, Flinders, Murchison, Grey, Fitzroy, Roper, and Victoria, rose on the edge of a sandstone table-land, and that this ridge also gave rise to streams which flowed towards the interior. Early efforts to cross to the Gulf of Carpentaria had resulted in the discovery of Cooper's Creek, now called the Victoria or Barcoo River, a stream which has been traced for more than 600 m., and which has a S.W. course towards the interior of the continent; and a supposition arose that the rivers draining the inner edge of the table-land flowed towards a great interior lake—a theory which was even older than that of the desert.

The first complete traverse of the continent was made by Burke and Wills who, in 1860–61, crossed nearly in the meridian of 142° E., finding creeks, grassy plains, and but a small extent of stony desert. Unfortunately, on their return southwards, their provisions ran short, they missed the party sent to their relief, and died of starvation on Cooper's Creek, their journals, however, being preserved by King, one of the party who was found when in the last stage of exhaustion. Mr. Stuart made several journeys northward from Adelaide, during one of which he discovered Central Mount Stuart, and found hills, grassy flats fit for sheep farms, and water either in creeks or easily to be obtained by digging. The eastern half of what was considered the central desert has been crossed three times by Stuart, and over the route by which he travelled a telegraph line has now been carried, and a connexion established between S. Australia and the mother country; also by Walker and Landsborough: and M'Kinlay passed from S. Australia by way of Carpentaria to Queensland driving a flock of sheep before him. M'Intyre and others have also traversed the continent; in fact, it has become quite common to cross from the Parroo to Carpentaria. In 1874 an expedition under Colonel Egerton Warburton, which, leaving the telegraph line 1120 m. N. of Adelaide city, succeeded in reaching Roebourne on the sea coast; while during the present year (1876) another under Mr. Giles has crossed the desert in the opposite direction, having gone from the 117th meridian eastward to the telegraph line: and overland routes have been found possible, though hardly convenient for traffic, between all the widely separated Australian colonies.

It is found that no great horseshoe lake, such as Lake Torrens was imagined to be, exists. In its place there is a group of lakes, Eyre, Gregory, Torrens, Frome, &c. The basin of Lake Eyre is only 70 ft. above the sea level.

The watershed of the northern part of the continent is on the edge of a sandstone plateau which runs from E. to W., and is found between 19° and 22° S. lat. In the W. this edge has an altitude of 800, and in the E. of 1900 to 2000 ft. above the sea. On the coast side the table-land is abrupt, and cleft with many beautiful valleys. Basalt and other igneous rocks are sometimes found protruding through the sandstone, and where this is the case the soil is of great fertility. To the N. of the plateau are long grassy flats, sometimes wooded; and succeeding these there are frequently mangrove swamps, where the rivers reach the sea. The table-land itself is rather bare, and the great S.W. slope, between 135° and 145° E., abounds in dividing ridges of sandstone, which, when broken up, present a desert-like

appearance, though very often good grass, fine soil, and gum forest are found. The rivers which run N. from the plateau flow in well defined beds; but those that flow southward have shallow beds, and are subject to both excessive inundation and evaporation at different times of the year. The watercourses of the interior drain to the Barcoo. Some break up into innumerable creeks and rills without definite direction. Bourke Creek, in lat. 25° S., long. 140° E., often causes immense inundations. The stony deserts, where they occur, seem to be the result of inundations, whose waters, when dried by rapid evaporation, leave the ground bare.

While the sun is N. of the equator, in the winter of the southern hemisphere, the winds are from the S.E. all over the N. part of the continent, with little and only occasional rain. These winds are the regular 'trades.' But in October and November, the wind changes to the N.W. monsoon and brings with it rain. The monsoon shifts back to the S.E. in April. In January, February, and March the heavy falls of rain and the soaked state of the soil give rise to the inundations in the neighbourhood of Bourke's Creek.

One of the results of Gregory's very interesting expedition in North Australia is the discovery of a table-land of sandstone of no great elevation that runs along the northern coast from Cambridge Gulf to the Gulf of Carpentaria, where it sinks down, its highest part being S. of Port Essington. This is part of the ring of higher land which forms the circumference of the Australian interior. It is traversed by the Rivers Adelaide, Roper, and Alligator; and the River Victoria extends to a considerable distance into the interior, and runs through a fertile region of more than 3,000,000 acres of the finest pasture land, which may in future become a flourishing British colony. The land at the Gulf of Carpentaria is fit for the cultivation of cotton and other tropical productions. Burketown has been founded at the bottom of the gulf; and an establishment on Sweer's Island has been commenced. The energy of the Australians does honour to the Anglo Saxon race in the perilous and disinterested journeys of discovery they have made under the greatest privation and difficulty.

However unpropitious the centre of the continent may be, there is abundance of fine country inland from the coast. All tropical productions might be raised, and in so large a continent there must be extensive tracts of arable land, though its peculiar character is pastoral. N. of Sydney, and in Queensland up to 16° S. lat., both cotton and silk are produced, as well as wines of excellent quality; and the higher land parallel to the coast is occupied by sheep and cattle farmers nearly to the Gulf of Carpentaria. There are large

forests on the mountains and elsewhere, yet that moisture is wanting which clothes other countries in the same latitudes with rank vegetation. In the colonies the clearing of a great extent of land has modified in some degree the mean annual temperature so that the climate has become hotter and drier, and not thereby improved.

§ 2. **The Island of Tasmania, or Van Diemen's Land.**—Tasmania, of triangular form, has an area of 26,215 sq. m., and is very mountainous. No country has a greater proportion of deep, commodious harbours, which occur in the N., S.E., and S. coasts; and as most of the rivers, though not navigable to any distance, end in arms of the sea, they afford secure anchorage for ships of any size. The mountain chain that traverses Tasmania in the form of the letter Z, separates it into two nearly equal parts, with a mean height of 3750 ft., and at an average distance of 40 m. from the sea. It encloses the basins of the Derwent and Huon Rivers, and, after sending a branch between them to Hobart Town, ends at South Cape. Its highest point is Ben Lomond (5010 ft.), in the N.E. The mountains of the W. consist of an elevated table-land, having a mean height of 3000 ft., midway between the N. and S. of the island, and sending off ranges on its W. side in various directions. The plateau embraces many peaks, the highest of which, Mount Humboldt (5520 ft.), is in the S.W. The offsets which shoot out in all directions are as savage and full of impassable chasms as the range itself. Frightful precipices occur. One in Ben Lomond has a perpendicular depth of 3000 ft. There are cultivable plains and valleys along the numerous rivers and large lakes by which the country is well watered; so that Tasmania is more agricultural and fertile than the adjacent continent, but its climate is wet and cold. The uncleared soil of both countries, however, is far inferior to that in the greater part of North or South America.[1]

§ 3. **Geology of Australia.**—Granite constitutes the entire base of the western portion of New South Wales, and extends far into the interior of the continent, bearing a striking resemblance in character to a similar portion of the Altäi chain described by Baron Humboldt. The central axis of the mountain range, in New South Wales and in Tasmania, is of granite, syenite, and quartz rock; but in early times there had been great invasions of volcanic substances, as many parts of the main chain, and most of its offsets, are of the older Plutonic rocks. The fossiliferous strata of the two colonies are mostly of the Palæozoic period, but their fossil fauna is poor as regards the number of species. Some are identical with,

---

1 Count Strzelecki.

and others are representatives of, those of other countries, even of England. There is an unbroken range of sandstone cliff from 200 to 500 ft. high of horizontal tertiary strata, which stretches from Southern Australia to Western Australia without a single valley or watercourse. As the flat country, wherever it has been traversed, is of the same structure, it is presumed that the low country throughout the interior of the Australian continent consists of horizontal tertiary beds, which are all more or less porous; the limestone strata are tolerably thin and interstratified with beds of sand. It appears, from the flora of the coal formation of these countries, that the vegetation was as distinct from that of the northern hemisphere at the Carboniferous period as it is at the present day.

The richness of the gold alluvium at the foot of the Australian Alps has changed the character of New South Wales from that of a thinly peopled pastoral country to one of the most rising and flourishing colonies that has sprung from the Anglo Saxon race. As early as 1844 Sir R. Murchison predicted that Australia, from the similarity in direction of its mountain chains, and of its rocks, with those of the Ural, then recently explored by him, would become one day a gold producing country, but no one could have foreseen its excessive richness. Both the chains in question, in those parts where gold is found, consist of metamorphic strata, of schist, sandstones, and limestones of the Palæozoic age, traversed by igneous rocks. But they differ in this respect, that while in the Ural the gold only exists on the eastern or Siberian side, in the Australian Alps it is on the western. Specimens were occasionally brought to Sydney by shepherds and labouring men, and as soon as it was known that gold was to be found in large quantities multitudes flocked to Australia from every quarter; and to such an extent had the search been carried that, in the year 1852, the province of Victoria yielded gold to the value of 8,375,128*l.* In addition to this, in the same year, New South Wales returned the amount of 2,212,534*l.*, making in all in one year from Australia 10,587,662*l.* sterling. In 1856, gold to the value of 12,633,138*l.* was found. The annual value of the gold exported by Australia, on the average of fifteen years, has been 10,000,000*l.*[1] During the early years of the discovery, the greater part was from the alluvial deposits on the earth's surface; but Australian gold, in future, will be chiefly obtained from the quartz formations in the mountain ranges, or in those which have to be

[1] The quantity of gold brought from California during the year 1857 amounted to 14,000,000*l.* sterling.

reached at great depths underground by mining operations and the sinking of shafts.

The principal *gold fields* in Victoria are the Ballarat district, W. of Melbourne; the Beechworth district, in the valley of the Ovens; the Sandhurst, or Bendigo district, N. of Mount Alexander; the Maryborough district, between the Avoca and the Lodden; the Castlemaine district, around Mount Alexander in the valley of the Campaspe; and the Ararat district, round Mount Ararat in the Pyrenees, N.W. of Ballarat.

Except at Ballarat, the gold now obtained is chiefly got by crushing the rock in which it is contained. The Rev. W. B. Clarke, an excellent geologist, pointed out the gold fields of the Snowy River, which descends to the S. from the high Alps at Mount Kosciusko, and he now has shown that a gold bearing country exists in Queensland, which is probably not less than 900 m. in length from S.E. to N.W. The Cape River gold field, about 200 m. inland from the seaport town of Bowen, is worked by a considerable number of miners.

§ 4. **Islands.**—Though the innumerable islands that are scattered through the ocean and seas differ much in size, form, and character, they have been grouped by M. von Buch into the two distinct classes of *Continental*, or those which are closely associated with the continent; and *Pelagic* islands, or those which appertain wholly to the sea (Gr. πέλαγος), and most of which are either of volcanic or coral formation.

Continental islands are long in proportion to their breadth, and follow each other in succession along the margin of the continents, as if they had been formed during the elevation of the mainland, or had subsequently been separated from it by the action of the sea, and still mark its ancient boundary. These islands, which follow one another in their elongated dimensions, generally run parallel to the maritime chains of mountains, and are mostly of the same structure, so that they suggest the idea of a submarine portion of the maritime range that has not yet completely emerged from the deep—or, if having sunk down, has not yet disappeared below the waves.

America offers numerous examples of this kind of island. On the N.W. coast there is a long chain of them, beginning with the New Norfolk group and ending with Vancouver Island, all similar and parallel to the maritime chain. Another range of continental islands occurs at the southern extremity of America, extending from Chiloe to Cape Horn, evidently an exterior range of the Patagonian Andes, and the S. prolongation of the granitic or coast chain of Chile; in the Gulf of Mexico, the ancient margin of the mainland is marked by the curved group of Porto Rico,

San Domingo, Jamaica, and Cuba, which nearly joins the peninsula of Yucatan. The various islands along the American coast of the Polar Ocean are probably the shattered fragments of the continent.

The old continent also affords innumerable examples; along the whole coast of Norway, from North Cape southwards, there is a continuous chain of rocky islands similar and parallel to the great range of the Scandinavian Alps; Great Britain itself, with the Hebrides, Orkney, and Shetland Islands, are remarkable instances of continental islands. It would be superfluous to mention the various instances which occur in the Mediterranean, where many of the islands are merely the prolongations of the mountain chains of the mainland rising above the sea, as Corsica, and Sardinia, which are an offset from the Maritime Alps.

The great central chain of Madagascar and its elongated form, parallel to the mountains and S.E. margin of the great African table-land, show that the island once formed part of the continent. Asia also abounds in similar instances, as Sumatra, Java, and the Moluccas; and another vast chain extends along the western coast from Formosa to Kamtschatka.

Pelagic islands have risen from the bed of the ocean, independently of the continents, and generally far from land. They are mostly volcanic, altogether or in part; often very lofty; sometimes single, and frequently grouped together; and each group has, or formerly had, a centre of volcanic action in one or more of the islands, round which the others have been formed. Many have craters of elevation; that is to say, they have been raised up in great hollow domes by the internal elastic vapours, and have either remained so, have become rent at the surface into gigantic fissures, or have collapsed into hollow cups, when the pressure from below was removed:[1] a considerable number have active vents.

The small islands and groups scattered at enormous distances from one another within the Antarctic Circle are all of volcanic formation, though none are active. In the Atlantic, Tristan da Cunha, St. Helena, Ascension, and Madeira are volcanic, though not now actively so; whereas the Cape de Verds, Canaries, and Azores have each burning volcanic vents:[2] the peak of Teyde (12,182 ft.) in Teneriffe is one of the most magnificent volcanic cones in the world.

---

[1] M. von Buch.

[2] These last two groups of islands have been admirably illustrated, since the publication of the first edition of this work, by the beautiful charts of Captains Arlett and Vidal, published by the Admiralty under the late Sir Francis Beaufort's direction. They are equally interesting to the geologist and to the navigator.

The labyrinth of islands scattered over the Pacific Ocean for more than 30 degrees on each side of the equator, and from the 130th meridian E. to Sumatra, which all but unites this enormous archipelago to the continent of Asia, has the group of New Zealand and the continent of Australia, with its appendage, Tasmania, on the S., and altogether forms a region which, from the unstable nature of the surface of the earth, is partly the wreck of a continent that has been engulfed by the ocean, and partly the summits of a new one rising above the waves. This extensive portion of the globe is in many parts *terra incognita* with regard to the interior of the islands, but is becoming every day less so.

§ 5. **New Zealand,** which is divided into three islands, North, South (Middle), and Stewart's Island, by rocky and dangerous channels, is superior to Australia in richness of soil, fertility, and beauty; it abounds in a variety of vegetable and mineral productions. High mountains, of volcanic origin, run through the islands which in the most northerly rise to 9195 ft. above the stormy ocean around, two thirds of their height buried in permanent snow and glaciers, exhibiting on the grandest scale all the Alpine characters, with the addition of active volcanoes on the E. and W. coasts: that of Tongariro pours fourth deluges of boiling water, which deposite vast quantities of siliceous sinter like the Geysers in Iceland; and such is the vitality of the vegetation that plants grow richly on the banks and even in water too hot to be endured. Broad and lofty mountains occupy the centre of North Island and send off densely wooded spurs to the sea coast. The island consists of a main body which sends off four great peninsulas, the most northerly of which is nearly cut through by Hauraki Gulf on the E. and Manakau Harbour on the W., on the narrow isthmus between which stands Auckland. S. of Tongariro is Ruapehu (9195 ft.), the highest summit in the central range. Mount Egmont (8270 ft.) near the S.W. corner of the island is an extinct volcano whose summit is covered with snow, and whose flanks are clothed with magnificent forests. The scenery is of extraordinary grandeur and beauty. Many of the streams rise in lakes. The largest lake is Taupo, 200 sq. m. in area, which gives rise to the Waikato River.

South, formerly *Middle, Island,* has the form of a parallelogram, broken by the great projection of Banks' Peninsula on the E. coast. It is traversed by a chain of mountains which runs much nearer to the W. than the E. coast, and which in the province of Canterbury reaches its greatest altitude in a range named the Southern Alps. Here Mount Cook towers 'like a large white tent' to a height of 13,200 ft., presenting a spectacle of great magnificence.

Mount Tyndall is over 11,000 ft. high; and the average height of this portion of the chain is more than 10,000 ft. Farther to the S., in Otago and Southland, the mountains rise from 4000 to 9000 ft.; and, as the snow line is at the height of 8000 ft., many of these summits are covered with perpetual snow. The glaciers of the Southern Alps are very grand; they descend in some instances to about 3000 ft. above the sea level. The Tasman Glacier, from Mount Cook, has a length of 18 m.; and at its terminal face (2772 ft. above the sea) its breadth is $1\frac{3}{4}$ m. There are many others of great extent; on the slopes of Mount Forbes are situated large glaciers which, after the melting of the snow or heavy rains, send down two waterfalls 800 ft. high. A series of lakes of glacial origin, and many of them of considerable extent, are found on the E. slopes of the mountains. The largest of these are Lakes Te Anau and Wakatipu, and the most picturesque, Lake Pukaki. The steep slopes are on the W. side; on the E. large lateral chains almost as high as the main chain, run N. and S. The valleys are covered with dense forests, and the mountain sides with Alpine and sub-Alpine vegetation. Five Passes between the E. and W. coasts have been explored, the lowest being the Haast Pass, 1716 ft. in elevation. The routes by Arthur Pass (3038 ft.) and the Harper Pass (3008 ft.) are, however, most likely to be preferred as they are shorter than that by the Haast Pass, are not often obstructed by snow, and not subject to avalanches. On the S.W. coast are a number of fjord-like openings. The aspect of the coast from Dusky Bay to Milford Sound is gloomy and forbidding in the extreme, with steep black mountains rising abruptly from the water's edge.

New Zealand has some fine *harbours* which are chiefly found on the E. coasts of the islands. It has much good land, and the grains, fruits, and timber trees of England flourish. Ferns and coniferæ abound. The kauri, or yellow pine, is found in the N.W. of North Island; the red, black, and white pines, the ironwood, the red, black, and white beeches, are among the native timber trees. Gold is worked in Auckland, Nelson, and Otago Provinces, and also on the W. coast of Canterbury Province, at Hokitiki, the yield in Otago almost rivalling that of the Australian gold fields. Iron is widely distributed; the beach of Taranaki (in North Island) is for miles formed of fine iron sand, which smelts into a metal equal to the best Staffordshire iron. The *climate* is varied, but has a greater annual rainfall than that of Great Britain, to which it is sometimes compared. The direction of the great mountain chain being athwart that of the almost constant winds from the Pacific, their influence on the climate is great. They break the force of the wind, and condense the moisture, which takes the form

of snow on the high summits. Earthquakes are common on both sides of Cook's Straits.

New Zealand is divided into eight provinces and one county—viz., Auckland, Taranaki, Wellington, and Hawke's Bay in the North Island; and Nelson, Marlborough, Canterbury, Otago, and the county of Westland in South Island. The much smaller Stewart's Island is uninhabited, and many think uninhabitable. it has, however, several safe harbours.

A very different scene from the stormy seas of New Zealand presents itself to the N. of Australia. There, vivified by the glowing sun of the equator, the islands of the Indian Archipelago are of matchless beauty, crowned by lofty mountains, loaded with aromatic verdure, that shelve to the shore or dip into a transparent glassy sea. Their coasts are cut by deep inlets, and watered by the purest streams which descend in cascades, rushing through wild crevices. The whole are so densely covered with palms and other forms of tropical vegetation that they seem to realise a terrestrial paradise.

§ 6. **New Guinea and the Aru Islands.**—*Papua* or *New Guinea*, the largest island in the Pacific after Australia and Borneo, is nearly 1500 m. long, from N.W. to S.E., and 450 broad in its widest part, with ridge rising above ridge, till they culminate in Peak Owen Stanley (13,205 ft.). Very little is as yet known about the interior of the island except that it is fertile, covered with luxuriant vegetation, and produces yams, sago, bananas, cocoa nuts, bread fruit, and large quantities of valuable timber. Storms are frequent; rain falls in torrents; earthquakes are rare and never violent. Great additions have been made to the knowledge of this island during the last few years by Mr. Wallace, Dr. Beccari, Captain Moresby, Mr. Stone, and others. Captain Moresby has surveyed its S.E. extremity and discovered a safe ship channel through the Louisiade reefs, opening up a good commercial route between Australia and China. He has added to the chart above 140 islands and islets, and has found many good harbours and safe anchorages.[1]

The *Aru Islands*, though low, have an undulating surface cut here and there into deep ravines. The rock everywhere is coralline limestone, from the cliffs of which the edible birds' nests of Aru are taken.

The forests are inhabited by birds of paradise and a great

[1] See 'Discoveries and Surveys in New Guinea,' &c., by Captain John Moresby, R.N., and Professor Giglioli's letters to the 'Geographical Magazine.'

variety of cockatoos and lories. The mother of pearl oyster, an inferior kind of pearl oyster, the tripang, a species of holothuria, and the shell tortoise are found on an extensive bank on the eastern side of the group, and the fishing for these is an important employment of the natives, who are of mixed races, great variety of feature—Malay, Papuan, and Jewish—and of colour being observable in the same community. Some are Christians, some Mohammedans, and others are heathens. From the similarity or identity of plants and animals, man included, Mr. Wallace thinks that the Aru group once formed part of New Guinea.

§ 7. **Borneo,** next in size to Australia, extending upwards of 800 m. from N. to S., and 600 from E. to W., and comprising an area of 289,000 sq. m., is a noble island. It is divided into two nearly equal parts by the equator, and appears to be traversed through its whole length by chains of mountains, which end in three branches at the Java Sea. Beautiful rivers flow from them to the plains, and several of these are said to spring from a spacious lake on the table-land in the interior, among the peaks of Keni-Balu (13,698 ft.). No European has visited this lake, but the Malay lake is known to be 24 m. long by 4 broad, and to be situated about 135 m. from the W. coast. Borneo possesses vast forests of ironwood, teak, and the gutta percha tree. Among the vegetable productions of this island are palms, bamboos, which are of infinite economical service to the Dyaks; ferns and tree ferns, pitcher plants, numerous orchids, few of which have conspicuous flowers; the mangosteen, and other tropical fruits, among which is the durian, to eat of which 'is a new sensation, worth a voyage to the East to experience.' Rice is largely grown. The vast forests are the home of the ourang outang, an animal which is confined to Sumatra and Borneo. Many of the mountains are exceedingly picturesque, and behind Saráwak is 'a most beautiful country, where limestone mountains with their fantastic forms and white precipices shoot up on every side draped and festooned with a luxuriant vegetation.' Borneo has no signs of recent volcanic action, and earthquakes are entirely unknown. It has a coast line of about 2000 m., with few bays and no great inlets, and its rivers have bars at their mouths, but beyond these they are deep. One of them has been navigated by a Dutch steamer for about 300 m. As yet only primary and secondary formations have been met with, but the mineral riches are very great. Diamonds, gold, iron, antimony, and coal are among its minerals; gums, gutta percha, and all kinds of spices and tropical fruits, are among its vegetable productions.

Situated in the centre of a vast archipelago, and in the direct line of an extensive and valuable commerce, it will in the course of

time become the seat of a great nation, whose civilisation and prosperity will hand down to posterity the name of the enterprising, philanthropic Sir James Brooke, Rajah of Saráwak, with the highest honour to which man can aspire. The climate is healthy, tempered by sea breezes, and in some parts it is even European; the small island of Labuan and the adjacent coasts of Borneo, being rich in coal, and situated in the route of steam vessels between India and China, exercise very great influence on the trade between Europe and the Celestial Empire, and on the civilisation of the barbarous and piratical tribes of the Eastern Archipelago.

The little known and curiously shaped island of *Celebes* is free from volcanoes in its S. and central portions. The structure of the part of the island near Macassar is interesting. Limestone mountains rest on a basis of basalt, which occasionally forms low rounded hills between the more precipitous portions. Basalt is nearly always found in the rocky beds of the streams; and over a step of this rock, about 40 ft. high, come the beautiful falls of the Maros River. The N. part of the island, called Minahasa, has groups of fine volcanic peaks 6000 or 7000 ft. high. The country is very beautiful; 'noble palms and tree ferns, wooded hills and volcanic peaks, everywhere meet the eye.' Large coffee plantations exist in the district, and the people, from being head hunters, like the Dyaks, are rapidly adopting civilised habits. The beautiful Lake of Tondano is found at an elevation of 2000 ft., and the villages around it enjoy a comparatively temperate climate. Hot springs and mud volcanoes exist not far from the lake, and earthquakes are very frequent.

The *Malay Archipelago* has an extent of more than 4000 m. from E. to W., and of about 1300 from N. to S. Its expanse is equal to that between the extreme W. of Europe and Central Asia. Sumatra has an area about equal to that of Britain; Java, Luzon, and Celebes are each about the size of Ireland. Eighteen other islands are each as large as Jamaica, and more than 100 are as large as the Isle of Wight. The climate is uniform, and, with the exceptions of Timor and the adjacent islands, the islands of the archipelago are clothed with forest from the sea level to the tops of the highest mountain peaks. The dryness and peculiar vegetation of Timor are probably the results of the S.E. monsoon from Australia, which produces atmospheric conditions that make the vegetation and physical aspect of the adjacent islands resemble its own.

A shallow sea, under 50 fathoms, connects the great islands of Sumatra, Java, and Borneo with the Asiatic continent; while another shallow sea connects New Guinea and some of the adjacent islands to Australia. The productions of the islands

thus connected are similar, and in many cases identical with those of the adjacent mainlands. Between these regions extends a sea whose depth is nowhere less than 100 fathoms, and in this lie the Moluccas, Celebes, and the islands E. of Lombok to Timor. All the islands E. of Celebes and Lombok exhibit almost as close a resemblance to Australia and New Guinea in their natural productions as do the western islands to Asia. The Islands of Bali and Lombok, closely approximated as they are, are the places where the two regions meet most nearly, but are yet perfectly distinct. Many of the islands of the Archipelago are hardly known; the interior of the greater number has scarcely been explored; so that they offer a wide field of discovery to the enterprising traveller, and they are now of easier access, since the seas have been cleared of pirates by the exertions of Sir James Brooke and the officers of Her Majesty's Navy. The travels of Mr. A. R. Wallace have added much to our information with regard to this archipelago.

CHAPTER XV.

CORAL FORMATIONS, VOLCANIC ACTION, AND EARTHQUAKES.

§ 1. **Different kinds of Coral Formations.**—It is a singular circumstance that most of the smaller tropical pelagic islands in the Pacific and Indian Oceans are either volcanic or coralline; and it is a startling fact that in most cases where there are volcanoes the land is rising by slow and almost imperceptible degrees above the ocean, whereas there is every reason to believe that those vast spaces studded with coral islands or *atolls*[1] are actually sinking below it, and have been so for ages.[2]

There are *four different kinds* of coral formations in the Pacific and Indian Oceans, all entirely produced by the growth of organic beings, and their detritus; namely, *lagoon islands or atolls, encircling reefs, barrier reefs*, and *coral fringes*. They are all nearly confined to the tropical zones; the atolls to the Pacific and Indian Oceans alone.

An atoll or lagoon island consists of a chaplet or ring of coral, enclosing a lagoon or portion of the ocean in its centre. The average

---

[1] *Atoll* (Malayan *ator* = 'order,' 'rank') is the name given to the sea lagoons and their enclosing coral reefs.

[2] Dr. Darwin on 'Coral Reefs.'

breadth of the coral ring of an atoll above the surface of the sea is about a quarter of a mile, often less, and it seldom rises higher than from 6 to 10 or 12 ft. above the waves. Hence the lagoon islands are not discernible, even at a very small distance, unless when they are covered with the cocoa nut palm, or the pandanus, as is frequently the case. On the outer side this ring or circlet shelves down to the distance of 100 or 200 yards from its edge, so that the sea gradually deepens to 25 fathoms, beyond which the descent is abrupt at angles varying from 40° up to absolute verticality. Even at the small distance of some hundred yards no bottom has been found with a sounding line a mile and a half long. All the coral below the surface of the water is alive—all above is dead, being the detritus of the living part, washed up by the surf, which is so heavy on the windward side of the tropical islands of the Pacific and Indian Oceans that it is often heard miles off, and is frequently the first warning to seamen of their approach to an atoll.

On the lagoon side, where the water is calm, the bounding ring or reef shelves into it by a succession of ledges, also of living coral, though not of the same species with those which build the exterior wall and the foundations of the whole ring. The perpetual change of water brought into contact with the external coral by the breakers probably supplies them with more food than they could obtain in a quieter sea, which may account for their more luxuriant growth. At the same time they deprive the whole of the coral in the interior of the most nourishing part of their food, because the still water in the lagoon, being supplied from the exterior by openings in the ring, ceases to produce the hardier corals; and species of more delicate forms, and of much slower growth, take their place. The depth of the lagoon varies, in different atolls, from 20 to 50 fathoms, the bottom being partly detritus and partly live coral. By the growth of the coral some few of the lagoons have been filled up; but the process is very slow, from the causes above assigned, and also because there are marine animals that feed on the living coral, and prevent its indefinite growth. The coral is of the most varied and delicate structure, and of the most beautiful tints; dark brown, vivid green, rich purple, pink, deep blue, peach-colour, yellow, with dazzling white, contrasted with deep shadows shine through the limpid water; while fish of the most gorgeous hues swim among the branching coral, which is of many different kinds, though all kinds combine in the structure of these singular islands. Lagoon islands are sometimes circular, but more often oval or irregular in form. Sometimes they are solitary, at other times in groups, but they occur most frequently in elongated archipelagoes, with the atolls elongated in the same direction. The grouping of

atolls bears a perfect analogy to the grouping of the archipelagoes of ordinary islands.

The size of these fairy rings of the ocean varies from 2 to 90 m. in diameter, and islets are frequently formed on the submerged part of the coral rings by the washing up of the detritus, for they are so low that the waves break over them in high tides or storms. They have openings or channels in their circuit, generally on the leeward side, where the tide enters, and by these ships may sail into the lagoons, which are excellent harbours, and even on the surface of the circlet or reef itself there are occasional boat channels between the islets.

Dangerous Archipelago, lying E. of the Society Islands, is one of the most remarkable assemblages of atolls in the Pacific Ocean. There are 80 of them, generally of a circular form, surrounding deep lagoons, and separated from each other by very deep channels. The reefs or rings are about half a mile across, and seldom rise more than 10 ft. above the edge of the surf, which beats upon them with such violence that it may be heard at the distance of 8 m.; and yet on that side the coral insects build more vigorously, and vegetation thrives better, than on the other. Many of these islets are inhabited.

The *Caroline Archipelago*, the largest of all, lies N. of the equator, and extends its atolls in 60 groups over 1000 sq. m. Many are of great size, and all are beaten by a tempestuous sea and by occasional hurricanes. The atolls in the Pacific Ocean and China Sea are beyond enumeration. Though less frequent in the Indian Ocean, none are more interesting, or afford more perfect specimens of this peculiar mode of formation, than the Maldive and Laccadive Archipelagoes, both nearly parallel to the coast of Malabar, and elongated in that direction. The former is 500 m. long, and about 50 m. broad, with atolls arranged in a double row, separated by an unfathomable sea, into which their sides descend with more than ordinary rapidity. The largest atoll is 88 m. long, and somewhat less than 20 broad; Suadiva, the next in size, is 44 m. by 23, with a large lagoon in its centre, to which there is access by 42 openings. There are inhabited islets on most of the chaplets or rings not higher than 20 ft., while the reefs themselves are nowhere more than 6 ft. above the water's edge.

The *Laccadives* are situated to the N. of the latter archipelago in a double line of nearly circular atolls, on which are low inhabited islets.

Encircling reefs differ in no respect from atoll reefs, except that they have one or more islands within their lagoon. They commonly form a ring around mountainous islands, at a distance of 2 or 3 m. from the shore, rising on the outside from a very deep ocean,

and separated from the land by a lagoon or channel 200 or 300 ft. deep. These reefs surround the submarine base of the island, and, rising by a steep ascent to the surface, encircle the island itself. The Caroline Archipelago exhibits good examples of this structure in the encircled islands of Hogoleu and Siniavin; the narrow ring or encircling reef of the former is 135 m. in its very irregular circuit, on which are a vast number of islets; 6 or 8 islands rise to a considerable height from its lagoon, which is so deep, and the opening to it so large, that a frigate might sail into it. The encircling reef of Siniavin is narrow and irregular, and its lagoon is so nearly filled by a lofty island that it leaves only a strip of water round it from 2 to 5 miles wide and 30 fathoms deep.

Tahiti, the largest of the Society Group, is another instance of an encircled island of the most beautiful kind; it rises in mountains 7000 ft. high, with only a narrow plain along the shore, and, except where cleared for cultivation, it is covered with forests of cocoa nut palms, bananas, bread fruit, and other productions of a tropical climate. The lagoon, which encompasses it like an enormous moat, is 30 fathoms deep, and is hemmed in from the ocean by a coral band of the usual kind, at a distance varying from half a mile to three miles.

Barrier reefs are of precisely the same structure as the two preceding classes, from which they only differ in their position with regard to the land. A barrier reef off the N.E. coast of the continent of Australia is the grandest coral formation existing. Rising at once from an unfathomable ocean, it extends 1200 m. along the N.E. coast, with a breadth varying from 200 yards to several miles, its distance from the shore being from 20 to 150 m. The great arm of the sea included between it and the land is nowhere less than 10, occasionally 60 fathoms deep, and is safely navigable throughout its whole length, with a few transverse openings by which ships can enter. It is interrupted off the S. coast of New Guinea by muddy water, probably from some great river on that island, in which the coral animals cannot live. There are also extensive barrier reefs on the islands of La Louisiade and New Caledonia, which are exactly opposite to the great Australian reef; and as atolls stud that part of the Pacific which lies between them, it is called the Coralline Sea. The rolling of the billows along the great Australian reef has been admirably described. 'The long ocean swell, being suddenly impeded by this barrier, lifted itself in one great continuous ridge of deep blue water which, curling over, fell on the edge of the reef in an unbroken cataract of dazzling white foam. Each line of breaker ran often one or two miles in length with not a perceptible gap in its continuity. There was a simple grandeur and display of power and beauty in this scene that

rose even to sublimity. The unbroken roar of the surf, with its regular pulsation of thunder as each succeeding swell fell first on the outer edge of the reef, was almost deafening, yet so deep toned as not to interfere with the slightest nearer and sharper sound. . . . Both the sound and sight were such as to impress the spectator with the consciousness of standing in the presence of an overwhelming majesty and power.'[1]

Coral reefs are distinct from all the foregoing: they are merely fringes of coral along the margin of a shore, and as they line the shore itself they have no lagoons. A vast extent of coast, both on the continents and islands, is fringed by these reefs, and as they frequently surround shoals they are very dangerous.

Lagoon islands are the work of various species of coral animals; but those particular zoophytes which build the external wall, the foundation and support of the whole ring or reef, are most vigorous when most exposed to the breakers; they cannot exist at a greater depth than about 15 fathoms, and die immediately when left dry; yet the coral wall descends precipitously to unfathomable depths; and although the whole of it is not the work of these animals, yet the perpendicular thickness of the coral is known to be very great, extending hundreds of feet below the depth at which these polypi cease to live. From an extensive survey of the Coralline Seas of the tropics, Dr. Darwin has found an explanation of these singular phenomena in the instability of the crust of the earth.[2]

§ 2. **Areas of Subsidence and Elevation in the bed of the Pacific.**—Since there are certain proofs that large areas of the dry land are gradually rising and others sinking down, so the bottom of the ocean is not exempt from the general change that is slowly bringing about a new state of things; and as there is evidence, on multitudes of the volcanic islands in the Pacific, of a rise in certain parts of the basis of the ocean, so the lagoon islands indicate a subsidence in others—changes arising from the expansion and contraction of the strata under the bed of the ocean.

There are strong reasons for believing that a continent once occupied a great part of the Pacific within the tropics some portion of which subsided by slow and imperceptible degrees. As parts of it gradually sank down below the surface of the deep, the tops of mountains and table-lands would remain as islands of different

---

[1] By Mr. Jukes, Naturalist to the Surveying Voyage of Captain Blackwood, R.N., in Torres Straits.

[2] During the American dredging expedition between Florida and the N. of Cuba, live corals were found at such vast depths as will change the received opinions as to the depth at which reef building corals may work, and will modify to a certain extent Darwin's theory of reefs, and their mode of growth.—*J. Gwyn Jeffreys, Esq.*

magnitude and elevation, and would form archipelagoes elongated in the direction of the mountain chains. Now, the coral animals which construct the outward wall and mass of the reefs never build laterally. Hence, if they began to lay the foundation of a reef on the submerged flanks of an island, they would be obliged to build the wall upwards in proportion as the island sank down, so that at length a lagoon would be formed between it and the land. As the subsidence continued, the lagoon would increase, the island would diminish, and the base of the coral reef would sink deeper and deeper, while the animals would always keep its top just below the surface of the ocean, till at length the island would entirely disappear, and a perfect atoll would be left. If the island were mountainous, each peak would form a separate island in the lagoon, and the encircled islands would have different forms, which the reefs would follow continuously. This theory explains perfectly the appearances of the lagoon islands and barrier reefs, the continuity of the reef, the islands in the middle of the lagoons, the different distances of the reefs from them, and the forms of the archipelago, so exactly similar to the archipelagoes of ordinary islands, all of which are but the tops of submerged mountain chains, and generally partake of their elongated forms.[1]

Every intermediate form between an atoll and an encircling reef exists: New Caledonia is a link between them. A reef runs along the N.W. coast of that island 400 m., and for many leagues never approaches within 8 m. of its shore; the distance increases to 16 m. near the S. extremity. At the other end the reefs are continued on each side 150 m. beyond the submarine prolongation of the land, marking the former extent of the island. In the lagoon of Keeling Atoll, situate in the Indian Ocean, 600 m. S. of Sumatra, many fallen trees, and a ruined store house, show that it has subsided: these movements took place during the earthquakes at Sumatra, which are also felt in this atoll. Violent earthquakes have been felt at Vanikoro (celebrated for the wreck of La Pérouse), a lofty

[1] Another theory relative to the formation of the lagoon islands is that the coral circuit is but the edge of a submarine elevation crater, on which the coral animals have raised their edifice. This view, which has been adopted by Von Buch and Captain Beechey, to whom we are indebted more than to any other navigator for positive information and admirable surveys of the coral islands in the Pacific, receives corroboration from the perfect conformity in shape between many of the lagoon islands of the Gambier group, and the known elevation craters, and from the circumstance of a lagoon island having been seen to rise in 1825, in lat. 30° 14′, accompanied with smoke, and communicating so high a temperature to the surrounding sea as rendered it impossible to land. See Beechey's 'Voyages' and Pöppig's 'Reise.'

island of the Queen Charlotte group, with an encircling reef in the western part of the South Pacific, and on which there are marks of recent subsidence. Other proofs are not wanting of this great movement in the beds of the Pacific and Indian Oceans.

The extent of the atoll formations, including under this name the encircling reefs, is enormous. In the Pacific, from the S. end of Low Archipelago to the N. extremity of Marshall Archipelago, a distance of 4500 m., and many degrees of latitude in breadth, atolls alone rise above the ocean. The same may be said of the space in the Indian Ocean between Saya de Malha and the end of the Laccadives, which includes 25° of latitude—such are the enormous areas that have been, and probably still are, slowly subsiding. Other spaces of great extent may also be mentioned, as the large archipelago of the Carolinas, that in the Coralline Sea of the N.W. coast of Australia, and an extensive one in the China Sea.

§ 3. **Volcanic Islands.**—Though the volcanic islands in the Pacific are so numerous there is not one within the areas mentioned, and there is not an active volcano within several hundred miles of an archipelago, or even group of atolls. This is the more interesting, as recent shells and fringes of dead coral, found at the various heights on their surfaces, show that the volcanic islands have been rising more and more above the surface of the ocean for a very long time.

The volcanic islands also occupy particular zones in the Pacific, and it is found, from extensive observation, that all the points of eruption fall on the areas of elevation.[1]

One of the most terribly active of these zones begins in Morty Island, to the N.E. of Gilolo, extends southward through Gilolo, and thence by Ternate, Tidore, Makian, Batchian, Amboyna, Banda, the Serwatty Islands, Flores, Sumbawa, Lombok, Bali, Java, and Sumatra, separated only by narrow channels, and altogether forming a curved line 2000 m. long; but as the volcanic zone is continued through Barren Island and Narcondam, in the Bay of Bengal, northward through the islands along the coast of Aracan, the entire length of this volcanic range is a great deal more. During the last hundred years all the islands and rocks for 100 m. along the coast of Aracan have been gradually rising. The greatest elevation of 22 ft. has taken place about the centre of the line of upheaval, in the N.W. end of the island of Cheduba, containing two mud volcanoes, and is continued through Foul Island and the Terribles.[2]

---

[1] Few books have more interest than Dr. Darwin's on 'Coral Reefs and Volcanic Islands,' to which the author is much indebted. Consult also the late Admiral Beechey's 'Voyages,' and his charts of the Coral Islands in the Pacific.

[2] By the Nautical Survey in 1848.

A violent volcanic eruption in 1646 rent open the island of *Makian* and left a huge chasm which extended into the heart of the mountain. In 1860 the mountain was clothed with vegetation to its summit and contained 12 populous villages. After 215 years of rest the volcano burst forth again on December 29, 1862, altering the appearance of the mountain, destroying the inhabitants, and sending out such clouds of ashes that the air was darkened at Ternate, 40 m. off, and the growing crops of the adjacent islands were destroyed.

The little island of *Gounong-Api*, belonging to the Banda group, contains a volcano of great activity; and such is the elevating pressure of the submarine fire in that part of the ocean that a mass of black basalt, of such magnitude as to fill a bay 60 fathoms deep, rose up so quietly that the inhabitants were not aware of what was going on till it was nearly done. Timor and the other adjacent islands also bear marks of recent elevation.

There is not a spot of its size on the face of the earth that contains so many volcanoes as the island of *Java*.[1] A range of volcanic mountains, from 5000 to 14,000 ft. high, forms the central crest of the island, and ends to the E. in a series of 38 separate volcanoes with broad bases, rising gradually into cones. These volcanoes are chiefly arranged in two lines: one, beginning near Cape St. Nicholas, the N.W. extremity of the island, runs diagonally across to the S.W. headland on the Strait of Bali; the other, parallel to this, extends from the middle of the Strait of Sunda to the S. coast in the latitude of Cheribon. They all stand on a plain but little elevated above the sea, and each individual mountain seems to have been formed independently of the rest. Most of them are of great antiquity, and are covered with thick vegetation. Some are extinct, or only emit smoke; from others sulphureous vapours issue with prodigious violence; one has a large crater filled with boiling water; and a few have had fierce eruptions of late years. Regular lava streams never occur in Java. The island is covered with volcanic spurs from the main ridge, united by cross chains, together with other chains of less magnitude but not less active.

In 1772 the greater part of one of the largest volcanic mountains was swallowed up after a short but severe combustion; a luminous cloud enveloped the mountain on August 11, and soon afterwards the huge mass actually disappeared under the earth with tremendous noise, carrying with it about 90 sq. m. of the surrounding country, 40 villages, and 2957 of their inhabitants.

The N. coast of Java is flat and swampy, but the S. provinces are beautiful and romantic; yet in the lovely peaceful valleys the

[1] Sir Stamford Raffles on 'Java.'

stillness of night is disturbed by the deep roaring of the volcanoes, many of which are perpetually burning with slow but terrific action.

Java (with Madura) contains about 44,297 sq. m., an area nearly equal to that of England. The mountains are clothed to their summits with luxuriant vegetation; and their lower slopes are covered with forests and plantations. At above 8000 ft. many plants closely allied to those of Europe are to be found. The tree ferns of Java form a very distinguishing feature in its vegetation. Hundreds of square miles of country are under terrace cultivation; the country is thickly peopled; and scattered throughout the island, especially in the eastern part of it, there are to be found the remains of ancient cities, temples, tombs, and statues which point to the existence of an advanced civilisation more than 400 years ago.

Separated from it by a narrow channel of the sea, *Bali* is but a continuation of Java, the same in nature and structure, but on a smaller scale, the mountains being little more than 8000 ft. high.

Lombok and *Sumbawa* are alike in structure. They are mountainous and volcanic. The intensity of the volcanic force under this part of the Pacific may be imagined from the eruption of Tomboro, in Sumbawa, in 1815, which continued from April 5 till July. The explosions were heard at the distance of 970 m.; and in Java, at the distance of 300 m., the darkness during the day was like that of deep midnight, from the quantity of ashes that filled the air: they were carried to Bencoolen, a distance of 1100 m.; the country round was ruined, and the town of Tomboro was submerged by heavy rollers from the ocean.

The *mountains of Sumatra* rise abruptly from its western coast. They extend for hundreds of miles in parallel ridges, varying in height from 2000 to 5000 ft.; the highest peaks reaching an elevation of from 8000 to 10,000 ft. The elevated longitudinal valleys which are capable of irrigation and cultivation are well peopled. The eastern side of Sumatra is flat and little elevated. The rivers wind through the level eastern plain, and form extensive deltas at their mouths. The most important of these is the Palembang River, which is navigable for 200 m. from its mouth. The country is covered with magnificent forests.

In Sumatra the extensive granitic formations of Eastern Asia join the volcanic series which occupies so large a portion of the Pacific. This most beautiful of islands presents the boldest aspect; it is indented by arms of the most transparent sea, and watered by innumerable streams; it displays in its vegetation all the bright colouring of the tropics. Here the submarine fire finds vent in three volcanoes on the S., and one on the N., side of the island. A few

atolls, many hundreds of miles to the S., show that this volcanic zone alternates with an area of subsidence.

More to the N., and nearly parallel to the preceding zone, another line of volcanic islands begins to the N. of New Guinea, and passes through New Britain, New Ireland, Solomon Islands, and the New Hebrides, containing many open vents. This range or area of elevation separates the Coralline Sea from the great chain of atolls on the N. between Ellice Group and the Caroline Islands, so that it lies between two areas of subsidence.

The third and greatest of all the zones of volcanic islands begins in North Celebes, 200 m. W. of the first belt, and passes by Siao and Sangir through the Philippine Islands and Formosa: bending thence to the N.E., it passes through Loo-Choo, the Japan Archipelago, and is continued by the Kurile Islands to the peninsula of Kamtschatka, where there are several volcanoes of great elevation.

The width of the volcanic belts in the Malay Archipelago is about 50 m.; but for a space of 200 m. on each side of them there are evidences of subterranean action in recently elevated coral rock, or in barrier coral reefs, indicating recent submersion. Borneo, New Guinea, and the whole of Celebes, except the eastern end of its northern peninsula, are non-volcanic.

That long chain of volcanic islands which forms the empire of Japan was little known to Europeans until recently: the Dutch were the first Europeans who had any intercourse with them; the United States have a commercial treaty with them; and, as a result of treaties, six ports—Yedo, Hakodadi, Kanagawa, Nagasaki, Osaka, and Hiogo—are now open to the British; so that 38 millions of new people are brought into intercourse with Europe.

The *Japanese islands*, so far as they are known to Europeans, are mountainous, spurs of the principal ranges coming in places close to the sea; and hills being everywhere prominent features of the landscape. 'All level ground in Japan,' says Sir Rutherford Alcock, 'would seem, indeed, but circumscribed plains or valleys of variable dimensions, in great contrast to the dead level and all but boundless plains of the great river courses of China.' The mountain scenery is extremely picturesque, the hills being generally clothed to the summits with trees—many of them of the family of the pines; and their lower slopes are frequently cultivated in terraces. Much of the soil is exceedingly fertile, and within 100 m. of Yedo it consists exclusively of dark rich mould. Some of the mountainous districts show distinct evidences of the volcanic agency which is so active throughout the land; and the principal mountain, Fusi-Yama (Rich Scholar Peak), in the island of Nippon,

is a volcano, whose latest recorded eruption was in 1707. Fusi-Yama was ascended by Sir Rutherford Alcock and his party. The flanks of the mountain are clothed with magnificent forests of oak, pine, and beech; but the ascent of the upper half of the mountain was over lava and scoriæ, getting more rough and precipitous as the summit was neared. The crater is a great oval opening, about 1100 yards in length, with a mean width of 600 and a depth of 350 yards. The estimated height of the crater above the sea level was 13,977 ft., and that of the highest peak, 14,177 ft. Fusi-Yama is a sacred mountain and an object of pilgrimages, which are performed in July and August, the only months in which the mountain is sufficiently clear from snow to allow the ascent to be made. This great peak forms a fine object in the landscape and can be seen from Yedo. Earthquakes are extremely common, and one which took place in 1783 rivalled that of Lisbon in its destructiveness. Another in 1854 did much damage in Yedo. Hot springs are common; those of Atami were visited by Sir R. Alcock. The Lake Hakoni, a fine sheet of water surrounded by hills and situated at an elevation of 6250 ft. above the sea level, lies N. of Fusi-Yama in a beautiful and secluded spot. The Japanese are skilful agriculturists and gardeners. Much grain, particularly rice, is grown; and great care is bestowed on the cultivation of flowers, for which the people have a passion. Many new plants have lately been introduced into this country from Japan. The Japanese are dexterous manufacturers in the metals, clever draftsmen, and make excellent maps of their country. The country is rich, and the people are industrious, laborious, clean, neat, and orderly.

There are six islands E. of Jephoon in the Japan Archipelago, which are subject to eruptions, and the internal fire breaks through the Kurile Islands in 18 vents, besides having raised two new islands in the beginning of this century, one four miles round, and the other 3000 ft. high, though the sea there is so deep that the bottom has not been reached with a line 200 fathoms long.

Thus some long rent in the earth has extended from the tropics to the gelid seas of Okhotsk and the peninsula of Kamtschatka: a new one begins to the E. of the latter in the Aleutian Islands, which are of the most barren and desolate aspect, perpetually beaten by the surge of a restless ocean, and bristled by the cones of 24 volcanoes; they sweep in a half moon round Behring Sea till they join the volcanic peninsula of Aliaska.

The line of volcanic agency has been followed far beyond the limits of the coral working animals, which extend but a short way on each side of the tropics; but it has been shown that in the equatorial regions immense areas of elevation alternate with as great

areas of subsidence: N. of Australia they are so mixed that a point of convergence is indicated.[1]

§ 4. **Volcanic Action on the Andean shore of the Pacific.**—On the other side of the Pacific the whole chain of the Andes, and the adjacent islands of Juan Fernandez and the Galapagos, form a vast volcanic area, which is actually now rising; and though there are few volcanic islands N. of the zone of atolls, yet what there are indicate great internal activity, especially in the Sandwich Islands where the volcanoes of Hawaii are inferior to none in awful sublimity. That of Kilauea (3970 ft.), a lateral crater of eruption of the great central volcano of Mauna Loa, was seen in high activity by Mr. Douglas in 1834, subsequently by Mr. Dana, and in March and April, 1868, it vomited forth torrents of lava, which devastated the S. part of the island. During this last eruption the floor of the crater sank some hundreds of feet, and the column of smoke was visible at Lahaina, 120 m. distant. The crater is more than 3 m. in diameter, formed of solidified lava. It was 990 ft. deep in 1851; the bottom filled by a lake of liquid lava, in furious ebullition, occasionally spouting to the height of from 20 to 70 ft., whence streams of lava, hurrying along in fiery waves, were finally precipitated down an ignited arch, where the force of the lava was partly arrested by the escape of gases, which threw back huge blocks and literally spun them into threads of glass, which were carried by the wind like the refuse of a flax mill. Mr. Douglas says the noise could hardly be described—that of all the steam engines in the world would be a whisper to it; and the heat was so overpowering, and the dryness of the air so intense, that the very eyelids felt scorched and dried up.[1]

There are great volcanic mountains in Hawaii: viz. Rohala (9800 ft.), Mauna Kea (13,953 ft.), Hualalai (7822 ft.), and Mauna Loa (13,760 ft.).

The Pacific, which contains various volcanic areas of vast extent and intense energy, is itself the most magnificent volcanic basin on the globe. Beginning at Graham's Land in the Antarctic Ocean it passes to the volcanoes in Tierra del Fuego, along the chain of the Andes, the Central American and Mexican volcanoes, and the scattered chain of volcanoes along the W. coast of N. America, to Mount St. Elias, in 60° N. at the N. extremity of the Pacific. From Mount St. Elias there is an almost unbroken line of mountain and volcano in the Aleutian Archipelago, carried down through the great elevated peninsula of Kamtschatka, the Kurile Isles, Yezo,

---

1 Darwin on 'Volcanic Islands.'

2 Mr. Douglas's 'Voyage to the Sandwich Isles in 1833–4,' in 'Journal of the Royal Geographical Society of London,' 1855.

Japan, the Philippines, and to the N. of New Guinea, by its volcanoes, and those of New Britain, the Solomon Isles, Egmont, New Hebrides, New Caledonia, and New Zealand, to the Antarctic ice again, at the Balleny Islands and Buckle Volcano, possibly to Victoria Land. In this enormous circuit the elevated ridge of the basin is of vast altitude on the American continent; but on the other side the ridge is frequently subaqueous, only rising into heights at intervals, though probably continuous throughout.

§ 5. **Volcanic Region of the Red Sea.**—At the head of the Red Sea, between the 12th and 16th parallels of N. lat., there is a volcanic region covering an area of 10,000 sq. m., without interruption, which is perhaps the third or fourth in extent on the surface of the earth. The Jebel-Tear is still smoking, and one of the Zugar Islands was in eruption in 1846. The volcano of Aden has been submerged and elevated again since the last period of its activity.[1]

It may be observed that where there are coral fringes the land is either rising or stationary; for were it subsiding lagoons would be formed. On the contrary, there are many fringing reefs on the shores of volcanic islands along the coasts of the Red Sea, the Persian Gulf, and the West Indian Islands, all of which are rising. Indeed, this occurrence in numberless instances coincides with the existence of upraised organic remains on the land.

As the only coral formations in the Atlantic are fringing reefs, and as there is not one in its central expanse, except in Bermuda, it may be concluded that the bed of the ocean is not sinking; and with the exception of the Leeward Islands, the Canaries, the Azores, and the Cape de Verd groups, there are no active volcanoes in the islands or on the coasts of that ocean.

§ 6. **Volcanic Action on the Great Continent.**—At present the great continent has few centres of volcanic action in comparison with what it once had. The Mediterranean is still undermined by fire which occasionally finds vent in Vesuvius and the stately cone of Etna. Though Stromboli constantly pours forth inexhaustible showers of incandescent matter, and a temporary island now and then starts up from the sea, the volcanic action has not diminished: Vesuvius has been several times in eruption within the last few years, the eruption of December 1861 having nearly destroyed the populous town of Torre del Greco for the second time in a century; and the activity of the mountain having been great ever since (1869).

The table-land of Western Asia, especially Azerbaijan, was once the seat of intense commotion, now spent, as evidenced by

---

[1] Dr. Buist.

the volcanic peaks of the Seiban Dagh, Ararat, and by the still smoking cone of Demavend.

The range of the *Thian Shan*, or Celestial Mountains, supposed by Humboldt and Ritter to be volcanic, has been shown by the actual research of Schrenk, Semenof, Severtzof, and Sosnofsky to have no volcanoes, and to be destitute of typical volcanic phenomena and even of volcanic forms. Sulphur has been found issuing from some fissures in the form of vapour, but this may be accounted for by the combustion of some of the numerous coal seams in the basin of the Ili River, which rises in the Thian Shan, and flows N.W. into Lake Balkash.[1] In the range of Tarbagatai, in the country of the Kirghiz, there is a mountain said to emit smoke and even flame, which produces sulphur and sal-ammoniac in abundance. The group of hot springs near the salt lake Kiook-Kiul and the valley of the Nubra, discovered by the brothers Schlagintweit in 1856, during a journey from Ladak to Khotan, across the Karakoram chain, shows that volcanic action still exists to the S. of the Thian Shan, and that the Karakoram is probably a volcanic formation, as was suspected by Humboldt. These gentlemen were the first Europeans who crossed that mighty chain of Central Asia, which is so lofty that some of the peaks they measured were 24,000 ft. high. It is not ascertained that there are any mountains in China that eject lava, but there are many fire hills and fire springs; the latter are real Artesian wells, 5 or 6 inches wide, and from 1500 to 3000 ft. deep; from some of these rises water containing much common salt; from others gases issue; and when a flame is applied, fire rushes out with great violence, rising 20 or 30 ft. high, with a noise like thunder. The gas, conducted in tubes of bamboo cane, is used in the evaporation of salt water from the neighbouring springs.

§ 7. **Number and General Description of Active Volcanoes.**—There are altogether about 270 active volcanoes, of which 190 are on the shores and islands of the Pacific.[2] They are generally disposed in lines or groups. The chain of the Andes furnishes a magnificent example of linear volcanoes. The Peak of Teneriffe, encompassed by the volcanic islands of Palma and Lancerote, is an equally good specimen of a central group. Erup-

---

1 See Schuyler's 'Turkistan,' vol. ii. p. 133.

2 'The number of active volcanoes on sea coasts and in islands is probably connected with the agency of water in volcanic operations. The latest chemical observations on the products of recent eruptions favour the doctrine that large bodies of salt water gain access to the volcanic foci.' Steam or aqueous vapour may propel lava to the surface; and 'various gases, rendered liquid by pressure at great depths, may aid in causing volcanic outbursts, and in fissuring and convulsing the rocks during earthquakes.'—Lyell's 'Principles of Geology,' 10th edition, 1868.

tions are much more frequent in low than in the more elevated volcanoes; that in the island of Stromboli is in constant activity; whereas Cotopaxi, and Tunguragua, in the Andes, have only been active once in a hundred years. On account of the force requisite to raise lava to such great elevations, it rarely flows from very elevated cones. Antisana is the only instance to the contrary among all the lofty volcanoes of Equatorial America. In Etna, as in the volcano of Hawaii also, the pressure is so great that the lava forces its way through the sides of the mountain, or at the base of the cone. The same generally happens in Vesuvius, the great lava eruptions being chiefly from the base of the cone.

An eruption begins by a dense volume of smoke issuing from the crater, mixed with aqueous vapour and gases; then masses of rock and molten matter in a half fluid state are ejected with tremendous explosion and violence; after which lava begins to flow, and the whole terminates by a shower of ashes from the crater—often the most formidable part of the phenomenon, as was experienced at the destruction of Pompeii. There are several volcanoes which eject only streams of boiling water, as the Volcano de Agua, in Guatemala; others pour forth boiling mud, as in the Islands of Trinidad, Java, and Cheduba, in the Bay of Bengal. A more feeble effort of the volcanic force appears in the numerous solfataras. Hot springs show that the volcanic fire is not extinguished, though not otherwise apparent. To these may be added the emanations of boracic acid, in a gaseous form, acidulous springs, those of naphtha, petroleum, and various kinds of gas, as carbonic acid, the food of plants—and, when breathed, the destruction of animals, as is fearfully seen in the Guevo Upas, or 'Valley of Death,' in Java: it is half a mile in circumference, and about 35 ft. deep, with a few large stones, and not a vestige of vegetation on the bottom, which is covered with the skeletons of human beings and the bones of animals and birds blanched white as ivory. On approaching the edge of the valley, which is situate on the top of a hill, a nauseous sickening sensation is felt, and nothing that has life can enter its precincts without being immediately suffocated.[1]

The seats of activity have been perpetually changing, but there always has been volcanic action, possibly more intense in former times; but even at present it extends from pole to pole.

§ 8. **Earthquakes.**—Notwithstanding the numerous volcanic vents in the globe, many places are subject to violent earthquakes, which destroy the works of man and often change the configuration of the country. The most extensive district of earthquakes comprises the Mediterranean and the adjacent countries, Asia

---

[1] Letter from Alex. Loudon, Esq., in the 'Journal of the Geographical Society of London.'

Minor, the Caspian Sea, Caucasus, the Persian mountains, and the W. border of the S. American continent. A great part of the continent of Asia is more or less subject to shocks; but with the exception of the shores of the Red Sea and the northern parts of Barbary, Africa is entirely free from these tremendous scourges; and it is singular that, notwithstanding the terrible earthquakes which shake the countries west of the Andes, the Andean chain itself, and all the countries round the Gulf of Mexico and the Caribbean Sea, they are extremely rare in the great eastern plains of South America. Greenland, Spitzbergen, and great part of Australia also seem to enjoy an immunity from the attacks of earthquakes. For the most part the shocks are transmitted in the line of the primary mountain chains, and seem often to be limited by them in the other direction. The estuaries of the Indus and Ganges, the coasts of Siam and Eastern China, constitute a depressed continental earthquake range. The Pyrenees, Apennines, Balkan, and Caucasus, are all points of intensity on a line of mountains interrupted by seas and broad valleys. The great centres of earthquake in Europe are actively volcanic—Hecla, Vesuvius, Etna, and Santorin.

Mr. Mallet, in his most interesting work on earthquakes, mentions that the Scandinavian peninsula is so connected with Iceland by the bed of the Northern Ocean that no marked convulsion happens in the one without being felt in the other. 'Scandinavia, itself one of the most remarkable masses of land in slow process of elevation, also shows its connection with internal action; and were it not that Iceland is pierced with numberless vents, broken and shattered in every direction by volcanic action that admits of no cessation or consolidation above, there can be no doubt that the destructive power of earthquakes would be manifested in the northern peninsula to a far more serious extent and intensity.'

There must be some singular volcanic action connected with Great Britain which has occasioned 255 slight shocks of earthquake, of which 139 took place in Scotland; they have been for the most part confined to the neighbourhood of Comrie, in Perthshire, in 1839; of the rest 14 took place on the borders of Yorkshire and Derbyshire, 30 in Wales, and 31 on the S. coast of England. Mr. Mallet ascertained that the direction of the wave of shock of the earthquake that happened in November 1852 was inclined to the horizon at an angle of 25° or 30°; and, assuming the origin to have been even somewhere between Great Britain and Lisbon, the depth of the focus must have been very great; that earthquake extended over the greater portion of the British Isles, the maximum disturbance on the surface being about Shropshire. The mean direction of the British earthquakes probably passes

through the focus of the Lisbon earthquakes and that of the Canary Islands.

§ 9. **Probable causes, and various kinds, of Earthquakes.**—Earthquakes, like volcanoes, are the result of the development of heat and chemical action at various depths in the interior of the globe. Fractures and sudden heavings and subsidences in the flexible crust of the globe result from the pressure of the liquid matter, vapour, and gases in its interior. 'The flexibility of certain parts of the earth's crust, as deduced from observations on earthquakes, may imply the continuous existence of vast reservoirs of melted matter beneath the surface, but such, nevertheless, as might hold a very subordinate place in the earth's crust.'[1] But whether the initial impulse be eruptive, or a sudden pressure upwards, the shock originating in that point is propagated through the elastic surface of the earth in a series of circular or oval undulations, similar to those produced by dropping a stone into a pool, and like them they become broader and lower as the distance increases till they gradually subside; in this manner the shock travels through the land, becoming weaker and weaker till it terminates. When the impulse begins in the interior of a continent, the elastic wave is propagated through the solid crust of the earth, as sound is through the air, and is transmitted from the former to the ocean where it is finally spent and lost, or, if very powerful, is continued in the opposite land. In 1854, when the town of Yedo was engulfed, and a Russian frigate was wrecked by the tremendous waves that repeatedly rolled on the beach of the island during a great earthquake, remarkable waves were recorded to have been observed on the coast of California a few hours afterwards. The earthquake of 1868, which was so destructive in Peru and Ecuador, ruined the strip of land at the western foot of the Andes, from Iburra in Ecuador to Iquique in Peru, 1200 m. in length, levelled to the ground the cities of Arequipa, Iquique, Arica, and Pasco, destroying 20,000 lives and 60,000,000*l*. worth of property. The earth opened in all the plains round Arequipa, old volcanoes burst forth, and where Cotacachi stood is now a lake. The wave which was seen from Arica to roll in and strike the mole to pieces came probably from a line in the sea parallel to the coast, where the most violent subterranean disturbance happened. From this tract as a centre the shock was propagated in all directions: to Australia, New Zealand, the Sandwich Islands, and California; passing in its course over one fourth of the circuit, and covering in

[1] Lyell's 'Principles of Geology,' 10th edition, 1868. See, however, Sir William Thompson's paper on the 'Internal Temperature of the Earth,' read before the British Association at Glasgow, September 1876.

surface an eighth of the area of the globe. At Arica and Iquique the earthquake was observed on April 13, at 5 P.M.; the water wave was felt at Chatham Islands on the 15th, between 1 and 2 A.M., and on the coast of New Zealand at 3 or 4 A.M.; at Sydney it occurred at 2.30 A.M.; at Hilo, in the Sandwich Islands, it was felt on the 14th, 15th, and 16th; and at San Pedro on the Californian coast, on the 15th. The velocity of the water wave per minute was 6½ m., and per hour above 400 m. Many of the great earthquakes, however, have their origin beneath the bed of the ocean, far from land, whence the shocks extend in undulations to the surrounding shores.

From observations of earthquakes recorded as being felt at sea, a great submarine active volcanic area, first noticed by M. Daussy, is believed to exist in the bed of the Atlantic, nearly midway between Cape Palmas on the W. coast of Africa and Cape San Roque on the coast of Brazil. This vast, disturbed, and perhaps partially igneous ocean floor can be no less than 9° in length from W. to E., and from 3° to 4° in breadth from N. to S. Within this area, equal in size to Great Britain, ships have been violently shaken, so that the crew thought they had struck on a rock, but on sounding found deep water: noises have been heard, tremblings felt; and on one occasion volcanic ashes or cinders were found on the surface of the sea when much agitated. This is an object of such high geological interest as to be worthy of being investigated by deep sea sounding.

No doubt many shocks of small intensity are imperceptible: it is only the violent efforts of the internal forces that can overcome the pressure of the ocean's bed, and that of the superincumbent water. The internal pressure is supposed to find relief most readily in a belt of great breadth that surrounds the land at a considerable distance from the coast, and being formed of débris, the internal temperature is in a perpetual state of fluctuation, which would seem to give rise to sudden flexures and submarine eruptions.

When the original impulse is a fracture or eruption of lava in the bed of the deep ocean, two kinds of waves or undulations are produced and propagated simultaneously—one through the bed of the ocean, which is the true earthquake shock, and coincident with this a wave is formed and propagated on the surface of the ocean, which rolls to the shore, and reaches it in time to complete the destruction long after the shock or wave through the solid ocean bed has arrived and spent itself on the land. The sea rose 50 ft. at Lisbon, and 60 at Cadiz, after the great earthquake; it rose and fell 18 times at Tangier on the coast of Africa, and 15 times at Funchal in Madeira. At Kinsale a body of water rushed into

the harbour, and the water in Loch Lomond in Scotland rose 2 ft. 4 in.—so extensive was the oceanic wave.[1] The height to which the surface of the ground is elevated, or the vertical height of the shock wave, varies from 1 in. to 2 or 3 ft. This earth wave on passing under deep water is imperceptible, but when it comes to soundings, it carries with it to the land a long flat aqueous wave; on arriving at the beach, the water drops in arrear from the superior velocity of the shock, so that at that moment the sea seems to recede before the great ocean wave arrives. It is the small forced wave that gives the shock to ships, and not the great one; but when ships are struck in very deep water, the centre of disturbance is either immediately or very nearly under the vessel.

Three other series of undulations are formed simultaneously with the preceding, by which the sound of the explosion is conveyed through the earth, the ocean, and the air with different velocities. That through the earth travels at the rate of from 7000 to 10,000 ft. per second in hard rock, somewhat less in looser materials, and arrives at the coast a short time before, or at the same moment with the shock, and produces the hollow sounds that are the harbingers of ruin; then follows a continuous succession of sounds like the rolling of distant thunder, formed first by the noise propagated in undulations through the water of the sea, which travels at the rate of 4700 ft. per second; and lastly by that passing through the air, which only takes place when the origin of the earthquake is a submarine explosion, and travels with a velocity of 1123 ft. per second. The rolling sounds precede the arrival of the great oceanic wave on the coasts, and are continued after the terrific catastrophe when the eruption is extensive.[2]

When there is a succession of shocks, all the phenomena are repeated. Sounds sometimes occur when there is no earthquake: they were heard on the plains of the Apure in Venezuela, at the moment the volcano in St. Vincent's, 700 m. off, discharged a stream of lava. The bellowings of Guanaxuato afford a singular instance: these subterranean noises have been heard for a month uninterruptedly, when there was no earthquake felt on the tableland of Mexico, nor in the rich silver mines 1600 ft. below its surface.

---

[1] Mitchell on the 'Causes of Earthquakes,' in 'Philosophical Transactions' for 1760.

[2] Thus, when an earthquake begins under the ocean, it occasions five distinct series of waves or undulations, all of which are subject to the same laws of motion, namely, the earth wave, the water wave, and three other series of waves arising from the passage of the sound of the explosion through the air, the earth, and the water. For the laws of Sound, see 'Connexion of the Physical Sciences.'

The *velocity* of the great oceanic wave varies as the square root of the depth; it consequently has a rapid progress through deep water, and a slower when it reaches to soundings. That raised during the earthquake at Lisbon travelled to Barbadoes at the rate of 7·8 m., and to Portsmouth at the rate of little more than 2 m. per minute. The velocity of the shock varies with the elasticity of the strata it passes through. The undulations of the earth are subject to the same laws as those of light and sound; so, when the shock or earth wave passes through strata of different elasticity it will be partly reflected and a wave will be sent back, producing a shock in a contrary direction, and partly refracted, or its course changed, so that shocks will occur both upwards and downwards, to the right or to the left of the original line of transit. Hence most damage is done at the junction of deep alluvial plains with the hard strata of the mountains, as in the great earthquake in Calabria A.D. 1783.

When the height of the undulations is small the earthquake will be a horizontal motion, which is the least destructive; when the height is great the central and horizontal motions are combined and the effect is terrible. The concussion was upwards in the earthquake which took place at Riobamba in 1797. Baron Humboldt mentions that some of the inhabitants were thrown several hundred feet high and across a river on to a neighbouring mountain. The worst of all is a verticose or twisting motion, which nothing can resist; it is occasioned by the crossing of two waves of horizontal vibration which unite at their point of intersection and form a rotatory movement. This and the interferences of shocks arriving at the same point from different origins or routes of different length, account for the repose in some places, and those extraordinary phenomena that took place during the earthquake of 1873 in Calabria, where the shock diverged on all sides from a centre through a highly elastic base covered with alluvial soil, which was tossed about in every direction. The dynamics of earthquakes have been ably discussed by Mr. Mallet in a very interesting paper in the 'Transactions of the Royal Irish Academy.'

There are few places where the earth is long at rest, for independently of those secular elevations and subsidences that are in progress over such extensive tracts of country, small earthquake shocks must be much more frequent than we imagine, though imperceptible to our senses, and only to be detected by means of instruments. The shock of an earthquake at Lyons in February 1822 was not generally perceptible at Paris, yet the wave reached and passed under that city, and was detected by the oscillation of the large declination needle at the Observatory, which had previously been at rest.

The undulations of some of the great earthquakes have spread to an enormous extent. The movement of the earthquake of 1868, which has been referred to, was felt from 8° S. to 42° S., and at Juan Fernandez. The earthquake that happened in 1842, in Guadaloupe, was felt over an extent of 3000 m. in length; and that which destroyed Lisbon had its origin in the bed of the Atlantic, from whence shocks extended over an area of about 700,000 sq. m., or a twelfth part of the circumference of the globe: the West Indian Islands, and the lakes in Scotland, Norway, and Sweden were agitated by it. In linear distance the effects of that earthquake extended through 300 m., the shocks were felt through a line of 2700 m., and the vibrations or tremors were perceptible in water through 4000 m. It began without warning, and in five minutes the city was a heap of ruins.

The earthquake of Calabria, in 1783, which completely changed the face of the country, only lasted two minutes; it was not very extensive, yet all the towns and villages for 22 m. round the small town of Oppido were utterly ruined. The destruction is generally accomplished in a fearfully short time: the earthquake at Caracas, in March 1812, consisted of three shocks, which lasted three or four seconds, separated by such short intervals that in 50 seconds 10,000 people perished. Baron Humboldt's works are full of interesting details on this subject, especially with regard to the tremendous convulsions in South America.

Sometimes a shock has been perceived underground which was not felt at the surface, as in the year 1802, in the silver mine of Marienberg in the Harz. In some instances miners have been insensible to shocks felt on the surface above, as happened at Fahlun in Sweden in 1823—circumstances in both instances depending on the elasticity of the strata, the depth of the impulses, or obstacles that may have changed the course of the terrestrial undulation. During earthquakes dislocations of strata take place, the courses of rivers are changed, and in some instances rivers have been permanently dried up; rocks are hurled down, masses raised up and the configuration of the country altered; but if there be no fracture at the point of original impulse there will be no noise.

§ 10. **Change in the Level of Land arising from Earthquakes.**—The power of the earthquake in raising and depressing the land has long been well known, but the gradual and almost imperceptible change of level through immense tracts of the globe is altogether a recent discovery; it has been ascribed to the expansion of rocks by heat, and subsequent contraction by the retreat of the melted matter from below them. It is not at all improbable that there may be motions like tides ebbing and flowing in the internal lava, for the changes are by no means confined to those enormous

elevations and subsidences that appear to be in progress in the basin of the Pacific and its coasts, nor to the Andes and the great plains E. of them—countries for the most part subject to earthquakes; they take place to a vast extent in regions where these convulsions are unknown. There seems to be an extraordinary flexibility in the crust of the globe from the 54th or 55th parallel of N. latitude to the Arctic Ocean. A line crosses Sweden from E. to W. in the parallel of 56° 3′ N. lat., along which the ground is perfectly stable and has been so for centuries. To the N. of it for 1000 m., between Gottenburg and North Cape, the ground is rising; the maximum elevation, which takes place at North Cape, being at the rate of 5 ft. in a century. At Gefle 90 m. N. of Stockholm it is about 2 or 3 ft. per century, and from thence it gradually diminishes to 6 in. per century at Stockholm. S. of the line of stability, on the contrary, the land is sinking through part of Christianstad and Malmo, for the village of Stassten in Scania is now 380 ft. nearer to the Baltic than it was in the time of Linnæus, who measured it. The coast of Denmark on the Sound; the island of Saltholm opposite to Copenhagen; and that of Bornholm are rising, the latter at the rate of a foot per century. The coast of Memel on the Baltic has actually risen 16 inches within the last 40 years, while the coast of Pillau has sunk down an inch and a half in the same period. The W. coast of Denmark, part of the Faröe Islands, and the W. coast of Greenland are all being depressed below their former level. In Greenland the encroachment of the sea, in consequence of the change of level, has submerged ancient buildings on the low rocky islands and on the mainland. The Greenlander never builds near the sea on that account, and the Moravian settlers have had to move inland the poles to which they moor their boats. It has been in progress for four centuries, and extends through 600 m., from Igalito Firth to Disco Bay.[1] Mr. Robert Chambers has shown that in our own country the land has been for ages on the rise, and that the parallel roads in Glen Roy, which have so long afforded matter of discussion, are merely margins left by the retreat of the water, as the land alternately rose and remained stationary. In the present day the elevation is going on in many places, especially on the Moray Firth and in the Channel Islands. The notice of this curious subject of the gradual changes of level in the land was chiefly revived by Sir Charles Lyell, in whose very instructive works on geology all the details will be found.[2]

---

[1] Captain Graah's Survey, in 1823–4 and Dr. Pingel, 1830–2.

[2] Lyell's 'Principles of Geology.' See also Dr. Darwin's observations

CHAPTER XVI.

THE ARCTIC AND ANTARCTIC REGIONS.

§ 1. **Arctic Lands.**—The continent of North America seems to have been shattered and broken up by the Polar Ocean into a vast number of fragments of great size all bearing more or less the severe character of Arctic lands. It may be that the land is sinking down or rising up, for in either case appearances would be the same, but the climate would improve in the first, and would be, if possible, more rigorous in the second. Immediately to the N. of the continent, land of great extent lies between 69° and 75° N. lat., and stretching nearly from 60° to 125° W. long. On the S. this mass of land is separated from the continent by the Dolphin, Union, and Dease Straits. The Arctic Ocean bounds it on the W.; the Straits of Banks, Melville, and Barrow, with Lancaster Sound, on the N.; and its E. limits are Davis Strait and Baffin Bay. It is divided into three parts, by Prince Regent Inlet and the Gulf of Boothia on the one hand, and by Prince of Wales Strait on the other. The eastern part, known as Cockburn Island, is intersected by various arms of the sea, respecting which little is known. The middle part contains Boothia, Victoria, Wollaston, and Prince Albert Lands. Banks Island is the westerly continuation; its northern coast was discovered by Sir Edward Parry, who gave it the name of Banks; and Captain M'Clure, in his voyage from Behring Strait, first discovered its most southerly point, Prince of Wales Strait, which separates it from Prince Albert Land, and afterwards all but circumnavigated the island. Besides these three principal parts, North Somerset Island, lying immediately S. of Barrow Strait, forms a northern continuation of Boothia, only separated from it by the narrow passage called Bellot Strait.

N. of that long line of narrow seas or straits that stretches from Banks Island to Baffin Bay, lie Prince Patrick, Melville, Byam Martin, Bathurst, and Cornwallis Islands, celebrated in the annals of Arctic discovery as Parry Lands. Beyond this is the great oceanic inlet of Wellington Channel, formerly the object of so much Arctic research, and forming its eastern side.

---

on the same subject, in the 'Voyage of the "Adventure" and "Beagle;"' M. Domeyko, 'Sur les Lignes d'ancien Niveau de l'Ocean du Sud, aux Environs de Coquimbo,' in 'Annales des Mines,' 1848; and for an illustration of the whole of this chapter, the maps of active volcanoes, of volcanic phenomena, and earthquakes, in Keith Johnston's 'Physical Atlases.'

The Island of North Devon lies more to the E., and ends in Baffin Bay; on the N. it is divided by Jones Sound from North Lincoln and Ellesmere Island, which has been traced as far as Victoria Head, in 78° 28′ 21″ N. lat, by Captain Inglefield, who discovered that it is separated from Greenland by Smith Sound, and who supposed that the latter is a strait leading from Baffin Bay into the Polar Ocean. A glimpse of the supposed open Polar Sea in this direction was obtained by Morton in Dr. Kane's celebrated expedition; afterwards Dr. Hayes reached a higher point in the strait and confirmed this important discovery. It was by Smith Sound that Captain Sherard Osborn advocated an attempt being made to reach the Pole itself, by sledging along the coast or across the ice in spring: but the Arctic Expedition of 1875–6 under Captain Nares has demonstrated the impracticability of reaching the Pole by this route and in this manner. The 'Alert' attained the limit of navigation on the S. shore of the impenetrable Polar Sea, and wintered in lat. 82° 27′. By laborious journeys over rugged ice, in which it was found impossible to get the sledges more than one mile a day, lat. 83° 20′ was made, at a spot 400 m. S. of the Pole. Her consort, the 'Discovery,' wintered in lat. 81° 44′.

§ 2. **Greenland,** the most extensive of the Arctic lands, begins with the lofty promontory of Cape Farewell, the S. extremity of a group of rocky islands, which are separated by a channel 5 m. wide from a table-land of appalling aspect, narrow to the S., but increasing in breadth northward to a distance of which above 2000 m. have been traced along the W. coast. This table-land, extending over an area of some 750,000 sq. m., is bounded by mountains rising from the deep in mural precipices, which terminate in needles and pyramids, or in parallel terraces, of alternate snow and bare rock, occasionally leaving a narrow shore. The coating of ice is so continuous and thick that the surface of the table-land may be regarded as one enormous field of ice, which overlaps the rocky edges 2000 ft. high, and dips in icy platforms through the fjords between the mountain peaks into the sea.

The coasts are beset with rocky islands, and cloven by fjords, some of which wind like rivers far into the interior. These deep inlets of the sea, now sparkling in sunshine, now shaded in gloom, are hemmed in by walls of rock often 2000 ft. high, whose summits are hid in the clouds. They generally terminate in glaciers, which are forced on by the pressure of the upper ice plains till they fill the fjord, and even project far into the sea like bold headlands; when undermined by the surge huge masses of ice fall from them with a crash like thunder, making the sea boil, and the commotion often extends to a distance of 16 m.

While travelling along the W. coast of Greenland, Dr. H. Rinks counted 23 icy platforms descending from the table-land into the fjords, and forcing the ice in many cases far into the sea, especially between 67½° and 73° N. lat. Now the thickness of the plain of ice cannot be less than the least diameter of the icebergs, which are its fragments; and as many icebergs are 100 or 150 ft. high and 4000 ft. in circumference, and since two thirds of their mass is under water, Dr. Rinks computes that between the preceding parallels the plain of ice covering Greenland must be 1000 ft. thick. These icy platforms are probably the chief sources of icebergs in Baffin Bay and Davis Strait, which, carried by currents, are stranded on the Arctic coast, or drawn into lower latitudes. The ice is very transparent and compact in the Arctic regions; its prevailing tints are blue, green, and orange, which, contrasted with the dazzling whiteness of the snow, and the gloomy hue of the rocks, produce a striking effect.

A great fjord in 68° N. lat. is supposed to extend completely across the table-land, dividing the country into S. and N. Greenland, which last extends to an unknown distance towards the Pole on the E. coast, which is altogether inaccessible from the frozen sea and ironbound shore, so that, except along the coast, it is an unexplored region. But on the W. side, Dr. Kane reached its northern termination in 82° 22′ N. lat., and 65° 35′ W. long., where it was washed by the Polar Ocean; so that it is unconnected with the polar lands to the W., and is consequently a great island. In some sheltered spots in S. Greenland, especially along the borders of the fjords, there are meadows where the service tree bears fruit, beech and willow grow by the streams, but not taller than a man; still farther N. the willow and juniper scarcely rise above the surface; yet this country has a flora peculiar to itself. S. of the Island of Disco, on the W. coast, Danish colonies and Moravian missionaries have formed settlements on some of the islands and at the mouths of fjords; the Esquimaux inhabit the coasts even to the N. extremity of Baffin Bay.

§ 3. **Spitzbergen.**—All the pelagic islands in the Arctic Ocean are highly volcanic, except Spitzbergen. In the great Archipelago of Spitzbergen the mountains spring sharp and majestic from the margin of the sea in dark gloomy masses, mixed with pure snow and enormous glaciers, presenting a sublime spectacle. Seven valleys filled by glaciers ending at the sea form a remarkable object on the E. coast. One of the largest masses of ice seen by Captain Scoresby on these islands extended 11 m. along the shore, N. of Horn Sound, with a sea face in one part more than 2000 ft. high. The sun is not seen for several months in the year, and the cold is consequently intense. Since 1858 the Swedes have sent five

scientific expeditions to Spitzbergen, and have greatly extended our knowledge of the geography and productions of this group of islands. Tertiary deposits have been found, with fossil plants, proving that the islands at that epoch had a temperate climate.

Although the direct rays of the sun are powerful in sheltered spots within the Arctic Circle the thermometer does not rise above 45° Fahr. July is the only month in which snow does not fall, and in the end of August the sea at night is covered with a thin coating of ice, and a summer often passes without a single warm day. The snow blink, the aurora borealis, the stars, and the moon, which when in her northern declination appears above the horizon for 10 or 12 days without intermission, furnish the principal light the inhabitants enjoy during their long and dreary winter.

§ 4. **Iceland** is 250 m. E. from Greenland, and lies S. of the Arctic Circle, which its most N. part touches. Though embracing an estimated area of nearly 40,000 sq. m., only about 16,000 sq. m. are habitable, the rest being a chaos of volcanoes and ice.

The peculiar feature of Iceland is a trachytic region, which seems to rest on an ocean of fire. It consists of two vast parallel table-lands covered with ice clad mountains, stretching from N.E. to S.W. through the centre of the island, separated by a longitudinal valley nearly 100 m. wide, which reaches from sea to sea. These mountains assume rounded forms, with long level summits or domes with sloping declivities, as in the trachytic mountains of the Andes and elsewhere; but such huge masses of tufa and conglomerate project from their sides in perpendicular or overhanging precipices, separated by deep ravines, that the regularity of their structure can only be perceived from a distance; they conceal under a cold and tranquil coating of ice the fiery germs of terrific convulsions, sometimes bursting into dreadful activity, sometimes remaining quiescent for ages. The most extensive of the two parallel ranges of Jökuls or Ice Mountains runs along the E. side of the valley, and contains Oraëfa Jökul (6408 ft.), the highest point in Iceland, seen like a white cloud from a great distance at sea: the western high land passes through the centre of the island.

Plains of ice cover a vast area in Iceland, and glaciers descending from the mountains push far into the lowlands. This tendency of the ice to encroach has materially diminished the quantity of habitable ground, and the progress of the ice plains is facilitated by the influence of the subterranean fire, which heats the superincumbent ground, and loosens the ice.

The longitudinal space between the mountainous table-lands is a low valley 100 m. wide, extending from sea to sea, where a substratum of trachyte is covered with lava, sand, and ashes, studded with low volcanic cones. It is a tremendous desert, never ap-

proached without dread even by the natives—a scene of perpetual conflict between the antagonistic powers of fire and frost, without a drop of water or a blade of grass; no living creature is to be seen —not a bird, nor even an insect. The surface is a confused mass of streams of lava rent by crevices; rocks piled on rocks, and occasional glaciers complete the scene of desolation. As herds of reindeer are seen browsing on the lichens that grow at its edges, it is presumed that some unknown parts may be less barren. The extremities of the valley are more especially the seats of perpetual volcanic activity. At the S. end, which opens to the sea in a wide plain, there are many volcanoes, of which Hecla is most known, from its insulated position, its vicinity to the coast, and its terrific eruptions. Between the years 1004 and 1766 twenty-three violent eruptions took place, one of which continued 6 years, spreading devastation over a country once the abode of a thriving colony, now covered with lava, scoriæ, and ashes: in the year 1846 it was in full activity. The eruption of the Skaptar Jökul, which broke out on May 8, 1783, and continued till August, is one of the most dreadful on record. The volcanic fire must have been in fearful commotion under Europe, for a tremendous earthquake ruined a wide extent of Calabria that year, and a submarine volcano had been burning fiercely for weeks in the ocean, 30 m. from the S.W. cape of Iceland. Its fires suddenly ceased, the island was shaken by earthquakes, when, at the distance of 150 m., they burst forth with almost unexampled fury in Skaptar. The sun was hid many months by dense masses of vapour, which extended to England and Holland, and clouds of ashes were carried hundreds of miles to sea. The quantity of matter thrown out in this eruption was computed at 50 or 60 thousand millions of cubic yards. The lava flowed in a stream in places from 20 to 30 m. broad and of enormous thickness, which filled the beds of rivers, poured into the sea nearly 50 m. from the place of its eruption, and destroyed the fishing on the coast. Some rivers were heated to ebullition, others dried up; the condensed vapour fell in snow and torrents of rain; the country was laid waste; famine and disease ensued; and during the next two years 1300 people and 150,000 sheep and horses perished. The scene of horror was closed by a dreadful earthquake. Previous to the explosion an ominous mildness of temperature indicated the approach of the volcanic fire towards the surface of the earth; similar warnings had been observed before in the eruptions of Hecla.

A semicircle of volcanic mountains on the E. side of Lake Myvatn is the focus of the igneous phenomena at the N. end of the great central valley. Leirhnukr and Krabla, on the N.E. of

the lake, have been equally formidable. After years of quiescence they suddenly burst into violent eruption, and poured such a quantity of lava into Lake Myvatn, which is 20 m. in circumference, that the water boiled many days. There are other volcanoes in this district no less formidable. Various caldrons of boiling mineral pitch, the shattered craters of ancient volcanoes, occur at the base of this semicircle of mountains, and also on the flanks of Mount Krabla: these caldrons throw up jets of the dark matter, enveloped in clouds of steam at regular intervals, with loud explosion. That which issues from the crater of Krabla must, by Mr. Henderson's description, be one of the most terrific objects in nature.

The eruptive *boiling springs* of Iceland are perhaps the most extraordinary phenomena in this singular country. All the great aqueous eruptions occur in the trachytic formation; they are characterised by their high temperature, by holding siliceous matter in solution, which they deposit in the form of siliceous sinter, and by the discharge of sulphuretted hydrogen gas. Numerous instances of spouting springs occur at the extremities of the great central valley, especially at its S. end, where more than 50 have been counted in the space of a few acres—some constant, others periodical—some merely agitated or stagnant. The Great Geyser and Strokr, 35 m. N.W. from Hecla, are the most magnificent; at irregular intervals they eject large columns of boiling water 100 ft. high enveloped in clouds of steam, with a tremendous noise. The tube of the Great Geyser whence the jet issues is about 10 ft. in diameter and 75 ft. deep; it opens into the centre of a basin 4 ft. deep and between 46 and 50 ft. in diameter; as soon as the basin is filled with boiling water that rises through the tube, explosions begin, the ground trembles, and the water is thrown to the height of 100 or 150 ft., followed by large volumes of steam. No further explosion takes place till the empty basin and tube are again replenished.

MM. Descloiseaux and Bunsen in 1846 found the temperature of the Great Geyser, at the depth of 72 ft., before a great eruption, to be 260½° Fahr., and after the eruption 251½°; an interval of 28 hours passed without any eruption. The Strokr (from *stroka* = 'to agitate'), 140 yards from the Great Geyser, is a circular well about 44 ft. deep, with an orifice of 8 ft., which decreases to about 10 inches at a depth of 27 ft. The surface of the water is in constant ebullition, while at the bottom the temperature exceeds that of boiling water by about 24°. The experiments of M. Donny of Ghent showed that water long boiled becomes more and more free from air, by which the cohesion of the particles is so much increased that when it is exposed to a heat sufficient to overcome the force of cohesion, the production of steam is so instantaneous

and so considerable as to cause explosion. To this cause he ascribes the eruptions of the Geysers, which are in constant ebullition for many hours, and become so purified from air that the strong heat at the bottom at last overcomes the cohesion of the particles, and an explosion takes place. The boiling spring of Tunquhaer in the valley of Reikholt is remarkable from having two jets, which play alternately for about 4 minutes each. Some springs emit gas only, or gas with a small quantity of water. Such fountains are not confined to the land or fields of ice; they occur also in the sea, and many issue from the crevices in the lava bed of Lake Myvatn, and rise in jets above the surface of the water.

A region of the same character with the mountains of the Icelandic desert extends due W. from it to the extremity of the long narrow promontory of the Snaefell Syssel, ending in the snowclad cone of the Snaefell Jökul (5964ft.), one of the most conspicuous mountains in Iceland. Trap rocks, occasionally 4000 ft. deep, which have been formed by streams of lava at very ancient epochs cover a great part of Iceland.

The dismal *coasts* are torn, except on the S., by fjords, penetrating many miles into the interior, and spreading into endless branches. In these fissures the sea is still dark, and deep, between walls of rock 1000 ft. high. The fjords, however, do not here, as in Greenland, terminate in glaciers, but are prolonged in narrow valleys through which streams and rivers run to the sea. In these valleys the inhabitants have their abode, or in meadows which have a transient verdure along some of the fjords, where the sea is so deep that ships find safe anchorage.

In the valleys on the N. coast, as they approach towards the Arctic Circle, the *soil* is wonderfully good, and there is more vegetation than in any other part of Iceland, except the E. shore, which is the most favoured portion of this desolate land. Rivers abounding in fish are more frequent there than elsewhere; willows and juniper adorn the valleys, and birch trees 20 ft. high grow in the vale of Lagerflest, the only place which produces them large enough for house building, and the verdure is fine on the banks of those streams which are heated by volcanic fires. The *climate* of Iceland is much less rigorous than that of Greenland, and it would be still milder were the air not chilled by the immense fields of ice from the Polar Sea which beset its shores.

The inhabitants are supplied with fuel by the Gulf Stream, which brings drift wood in great quantities from Mexico, the Carolinas, Virginia, and the River St. Lawrence; and some even from the Pacific Ocean appears to be drifted by currents round by the northern shores of Siberia. The *mean temperature* in the S. of the island is about 39° Fahr., that of the central districts 36°, and

in the N. it is rarely above the freezing point. The cold is most intense when the sky is clear, but that is a rare occurrence, as the moist wind from the sea covers mountain and valley with thick fog. Hurricanes are frequent and violent; and although thunder is seldom heard in high latitudes Iceland is an exception, for tremendous thunderstorms are not uncommon there—a circumstance attributed to the volcanic nature of that island, as lightning accompanies volcanic eruptions everywhere. At the N. end of the island the sun is always above the horizon in the middle of summer, and under it in mid winter, yet there is no absolute darkness.

The island of *Jan Mayen* lies between Iceland and Spitzbergen; it is the most N. volcanic country known. Its principal feature is the volcano of Beerenberg (6870 ft.), whose snowcapped cone, apparently inaccessible, has been seen to emit fire and smoke. It is flanked by enormous glaciers, like frozen cataracts, which occupy three hollows in an almost perpendicular cliff, descending from the base of the mountain to the sea.

The group of islands of *New Siberia*, which lie N. of the province of Yakutsk, and in about 78° of N. lat., have so rude a climate that they have no permanent inhabitants; they are remarkable for the quantity of fossil bones they contain: the elephants' tusks found there have for years been an article of commerce.

Franz Joseph Land is an archipelago in the Arctic Ocean about as large in area as Spitzbergen, and consisting of several large masses of land which are intersected by numerous fjords and skirted by many islands. It lies N. of Novaia Zemlia, between 80° and 83° N. lat., and was discovered by the Austrian North Polar expedition under Lieut. Payer in the spring of 1874. Parts of the country are described as very beautiful, but it is nowhere inhabited, save by a few ice bears.

§ 5. **Antarctic Lands.**—The S. Polar lands are equally volcanic and as deeply icebound as those in the N. Victoria Land, which from its extent seems to form part of a continent, was discovered by Sir James Ross who commanded the expedition sent by the British Government in 1839 to ascertain the position of the S. magnetic pole. This extensive tract lies S. of New Zealand; Cape North, its most N. point, is situate in 70° 31′ S. lat. and 165° 28′ E. long. To the W. of that cape the N. coast of this land terminates in perpendicular ice cliffs, from 200 to 500 ft. high, stretching as far as the eye can reach, with a chain of grounded icebergs extending for miles from their base, all of tabular form, and varying in size from 1 to 9 or 10 m. in circumference. A lofty range of peaked mountains rises in the interior at Cape North, covered with unbroken snow, only relieved from uniform whiteness by shadows produced by the undulations of the surface. The in-

dentations of the coast are filled with ice many hundreds of feet thick, which makes it impossible to land. To the E. of Cape North the coast trends first S.E. by E., and then in a southerly direction to 78¼° of S. lat., at which point it suddenly bends to the E., and extends in one continuous vertical ice cliff to an unknown distance in that direction. The first view of Victoria Land is described as most magnificent. 'On January 11, 1841, in about latitude 71° S., and longitude 171° E., the Antarctic continent was first seen, the general outline of which at once indicated its volcanic character, rising steeply from the ocean in a stupendous mountain range, peak above peak enveloped in perpetual snow, and clustered together in countless groups, resembling a vast mass of crystallisation, which, as the sun's rays were reflected on it, exhibited a scene of such unequalled magnificence and splendour as would baffle all power of language to pourtray, or give the faintest conception of. One very remarkable peak, in shape like a huge crystal of quartz, rose to the height of 7867 ft., another to 9096 ft., and a third to 8444 ft. above the level of the sea. From these peaks ridges descended to the coast, terminating abruptly in bold capes and promontories, whose steep escarpments, affording shelter to neither ice nor snow, alone showed the jet black lava or basalt which reposed beneath the mantle of eternal frost.' . . . . 'On the 28th, in lat. 77° 31′ and long. 167° 1′, the burning volcano, Mount Erebus (12,367 ft.), was discovered, enveloped in ice and snow from its base to its summit, from which a dense column of black smoke towered high above the other lofty cones and crateriferous peaks with which this extraordinary land is studded, from the 72nd to the 78th degree of latitude. Mount Terror (10,887 ft.) is an extinct crater near it, which has doubtless once given vent to fires beneath : it ends in a cape from which a vast barrier of ice extended in an E. direction, checking all farther progress S. This continuous perpendicular wall of ice, varying in height from 200 to 100 ft., its summit presenting an almost unvarying level outline, we traced for 300 m., when the pack ice obstructed all farther progress.'[1]

The vertical cliff in question forms a completely solid mass of ice about 1000 ft. thick, the greater part of which is below the surface of the sea; there is not the smallest appearance of a fissure throughout its whole extent, and the intensely blue sky beyond indicated plainly the great distance to which the ice plains reach southward. Gigantic icicles hang from every projecting point of the icy cliff, showing that it sometimes thaws in these latitudes, although in the month of February, which corresponds with August

[1] 'Remarks on the Antarctic Continent and Southern Islands,' by Robert MacCormick, Esq., Surgeon of H.M.S. 'Erebus.'

in England, Fahrenheit's thermometer did not rise above 14° at noon. In the North Polar Ocean, on the contrary, streams of water flow from every iceberg during the summer. The whole of this country is beyond the pale of vegetation; no moss, not even a lichen, covers the barren soil where everlasting winter reigns. Parry Mountains, a lofty range stretching S. from Mount Terror to the 79th parallel, is the most southern land yet discovered. The South Magnetic Pole, one of the objects of the expedition, would be situated in Victoria Land, in 75° 5′ S. lat., and 154° 8′ E. long., according to Sir James C. Ross's observations.

Various tracts of land have been discovered near the Antarctic Circle, and within it, though none in so high a latitude as Victoria Land. Whether they form part of one large continent remains to be ascertained. Scientific expeditions sent by the Russian, French, and American Governments have increased our knowledge of these remote regions, and the spirited adventures of British merchants and captains of whalers have contributed quite as much.[1] The land within the Antarctic Circle is generally volcanic—at least the coast line, which is all that is yet known, and that, being covered with snow and ice, is destitute of vegetation.

CHAPTER XVII.

MINERALS.

§ 1. **Nature and Character of Mineral Veins.**—The tumultuous and sudden action of the volcano and the earthquake on the great masses of the earth is in strong contrast with the calm, silent operations on the minute atoms of matter by which Nature seems to have filled the fissures in the rocks with her precious gifts of metals and minerals, sought for by man from the earliest ages to the present day. Tubal Cain was 'the instructor of every artificer in brass and iron.' Gold was among the first luxuries; and even in our own country, from time immemorial, strangers came from afar to carry off the produce of the Cornish mines.

The ancients scarcely were acquainted with a third of the metals now known, and the metallic bases of the alkalis only date from

---

[1] Captain Cook discovered Sandwich Island in 1772–5.—Captain Smith, of the brig 'William,' discovered New South Shetland in 1819.—Captain Billingshausen discovered Peter Island, and the coast of Alexander the First.—Captain Weddel discovered the Southern Orcades.—Captain Bisco discovered Enderby Land and Graham Land in 1832; Admiral Dumont d'Urville, la Terre d'Adelie in 1841; and Sir James Ross, Victoria Land in the same year.

the time of Sir Humphry Davy, having formed a remarkable part of his brilliant discoveries.[1]

---

[1] LIST OF ELEMENTARY BODIES.*

MONADS (=bodies of the same equivalent value as hydrogen).

Non-Metallic Bodies.†

		Atomic Weights.	Symbol.
	1. *Hydrogen*	1	H
Halogen elements.	2. Fluorine	19	F
	3. *Chlorine* (Scheele, 1774)	35·5	Cl
	4. Bromine (Balard, 1826)	80	Br
	5. Iodine (Courtois, 1811)	127	I

Metals.

		Atomic Weights.	Symbol.
Sodium elements.	6. Lithium (Arfwedson, 1818)	7	Li
	7. *Sodium* (Davy, 1807)	23	Na
	8. Silver	108	Ag
	9. *Potassium* (Davy, 1807)	39·1	K
	10. Rubidium (Bunsen, 1861)	85·4	Rb
	11. Cæsium (Bunsen, 1860)	133	Cæ

DIADS (=bodies whose equivalent value is twice that of hydrogen).

Non-Metallic Bodies.

		Atomic Weights.	Symbol.
Oxygen elements.	12. *Oxygen* (Priestley, 1774)	16	O
	13. *Sulphur*	32	S
	14. Selenium (Berzelius, 1817)	79·4	Se
	15. Tellurium (Müller, 1782)	128	Te

Metals.

		Atomic Weights.	Symbol.
Magnesium elements.	16. *Calcium* (Davy, 1807)	40	Ca
	17. Strontium (Davy, 1807)	87·6	Sr
	18. Barium (Davy, 1807)	137	Ba
	19. Beryllium or Glucinum (Wöhler, 1828)	9·3	Be or G
	20. *Magnesium* (Bussy, 1829)	24	Mg
	21. Zinc	65·2	Zn
	22. Cadmium (Stromeyer, 1818)	112	Cd
	23. Mercury	200	Hg
	24. Yttrium (not isolated)	61·7	Y
	25. Erbium (Bahr and Bunsen)	112·6	Eb
	26. Cerium (Klaproth, 1803)	92	Ce
	27. Lanthanum (Mosander, 1839)	93·6	La
	28. Didymium (Mosander, 1841)	95	Di
	29. Thorium (Berzelius, 1828)	231·4	Th
	30. Indium (Reich and Richter, 1872)	72	In

---

* See Jukes and Geikie's 'Manual of Geology,' p. 17.

† The division of elements into metals and non-metals is quite an arbitrary one. *Hydrogen* is related to the metals, lithium, sodium, potassium, and silver; *arsenic* is related to nitrogen; in fine, there is no chemical line of separation between the elements usually considered to be non-metallic and those usually regarded as metals.

Minerals are deposited in veins or fissures of rocks, in masses, in beds, and sometimes rolled fragments imbedded in gravel and

---

TRIADS (=bodies whose equivalent values are three times that of hydrogen).

Non-Metallic Body.

31. Boron (Davy, 1808)	11	B

Metals.

32. Gold	197	Au
33. Thallium (Lamy, 1862)	204	T

TETRADS (=bodies of four times the equivalent value of hydrogen).

	Non-Metallic Bodies.	Atomic Weights.	Symbol.	
	34. *Carbon*	12	C	
Silicon elements.	35. *Silicon* (Berzelius, 1810)	28	Si	Metals.
Silicon elements.	36. Titanium (Gregor, 1791)	50	Ti	Metals.
Silicon elements.	37. Zirconium (Klaproth, 1787)	89·6	Zr	Metals.
Silicon elements.	38. Tin	118	St	Metals.
	39. *Aluminium* (Wöhler, 1848)	27·4	Al	Metals.
	40. Lead	207	Pb	Metals.
Platinum elements.	41. Rhodium (Wollaston, 1804)	104·4	Ro	Metals.
Platinum elements.	42 Ruthenium (Claus, 1846)	104·4	Ru	Metals.
Platinum elements.	43. Palladium (Wollaston, 1803)	106·6	Pd	Metals.
Platinum elements.	44. Platinum (Wood, 1741)	197·4	Pt	Metals.
Platinum elements.	45. Iridium (Tennant, 1803)	196	Ir	Metals.
Platinum elements.	46. Osmium (S. Tennant, 1803)	192·2	Os	Metals.

PENTADS (=bodies of five times the equivalent value of hydrogen).

Non-Metallic Bodies.

Nitrogen elements.	47. Nitrogen (Rutherford)	14	N
Nitrogen elements.	48. Phosphorus (Brandt, 1769)	31	P

Metals.

Arsenic elements.	49. Arsenic (Brandt, 1733)	75	As
Arsenic elements.	50. Antimony	122	Sb
Arsenic elements.	51. Bismuth	210	Bi
Arsenic elements.	52. Vanadium (Del Rio, 1801)	51·37	V
Arsenic elements.	53. Niobium (Hatchett, 1801)	94	Nb
Arsenic elements.	54. Tantalum (Ekeberg, 1803)	182	Ta

HEXADS (=bodies of six times the equivalent value of hydrogen).

Metals.

Chrome elements.	55. Chromium (Vauquelin, 1797)	52·2	Cr
Chrome elements.	56. Molybdenum (Hjelm, 1782)	96	Mo
Chrome elements.	57. Tungsten (D'Elhujar, 1783)	184	W
Iron elements.	58. Manganese (Galm, 1774)	55	Mn
Iron elements.	59. *Iron*	56	Fe
Iron elements.	60. Cobalt (Brandt, 1733)	58·8	Co
Iron elements.	61. Nickel (Cronstedt, 1751)	58·8	Ni
Iron elements.	62. Copper	63·4	Cu
	63. Uranium (Klaproth, 1789)	120	U

sand, the detritus of water. Most of the metals are found in veins; a few, as gold, tin, iron, and copper ores, are disseminated through the rocks, though rarely. Veins are seldom in a straight line, yet they maintain a general direction, though in a zigzag form, striking downwards at a very high angle, seldom deviating from the perpendicular by so much as 45 degrees, and extending to variable depths. When passing through stratified rocks, they are for the most part accompanied by a depression of the beds on one side of their course, and by an elevation on the other; the throw, or perpendicular distance between the corresponding strata on the opposite sides of a vein, varies from a few inches to as much as 600 feet. The beginning or end of veins is scarcely ever known; but when explored they are found to begin abruptly, and, after continuing undivided to a greater or less distance, they branch into small veins.

Veins have been filled with substances foreign to them, which have probably been disseminated by sublimation from the interior of the earth. Nothing can be more certain than that the minute particles of matter are constantly in motion from the action of heat, from mutual attraction, and from electricity. Prismatic crystals of salts of zinc are changed in a few seconds into crystals of a totally different form by the heat of the sun: casts of shells are found in rocks, from which the animal matter has been removed, and its place supplied by mineral matter; and the excavations made in rocks diminish sensibly in size in a short time if the rock be soft, and in a longer time when it is hard—circumstances that show an intestine motion of the particles, not only in their relative positions, but in space, which there is every reason to believe is owing to electricity—a power which, if not the sole agent, must at least have co-operated essentially in the formation and filling of mineral veins.[1]

The magnetism of the earth is presumed to be owing to electrical currents circulating through its mass in a direction at right angles to the magnetic meridians. Mr. Fox has shown, from observations in the Cornish mines, that such currents do flow through all metallic veins. Now, as the different substances of which the earth is composed are in different states of electro magnetism, and are often interrupted by non-conducting rocks, the electric currents being stopped in their course act chemically on all the liquids and substances they meet with. Hence Mr. Fox concluded that not only the nature of the deposits must have been determined by their relative electrical conditions, but that the

[1] This subject is ably discussed by Mr. Leithart in his work on the formation and filling of metallic veins.

direction of the metallic veins themselves must have been influenced by the direction of the magnetic meridians; and in fact almost all the metallic deposits in the world are in parallel veins or fissures trending from E. to W., or from N.E. to S.W. Veins at right angles to these are generally non-metalliferous, and if they do contain metallic ores these are of a different kind. In some few cases both contain the same ore, but in very different quantities, and both veins are richer near the point of crossing than elsewhere.

Sir Henry de la Beche conceived that the continued expansion and elevation of an intensely heated mass from below would occasion numerous vertical fissures through the superincumbent strata, within which some mineral matters may have been drawn up by sublimation, and others deposited in them when held in solution by ascending and descending streams of water; even on this hypothesis the direction of the rents and the deposition of the minerals would be influenced by the electrical currents. But if veins were filled from below, the richest veins would be lowest, which is not the case in Cornwall, Mexico, or Peru, where they are generally richer near the surface than at great depths: this is particularly the case in the mines of the precious metals in America, where the greatest quantities of ore have been found near the surface—a fact that may be explained by supposing the mineral substances brought by sublimation from the interior of the earth, and deposited where the temperature was lowest at or near the surface in the rocks among which they are situated. The primum mobile of the whole probably lies far beyond our globe: we must look to the sun's heat, if not as the sole cause of electrical currents, at least as combined with the earth's rotation in their evolution.[1]

When veins cross one another, the veins traversed are presumed to be of prior formation to those traversing, because the latter are dislocated and often heaved out of their course at the point of intersection; and such is the case with the metalliferous veins, which are therefore the most recent. Veins are rarely filled in every part with ore; they contain sparry and stony matter called the matrix with here and there irregular masses of the metallic ores, often of great size and value. Solitary veins are generally unproductive, and veins are richer when near one another. The prevalence and richness of mineral veins are intimately connected with the proximity or junction of dissimilar rocks, where the electro molecular and electro chemical actions are most energetic. Granite, porphyry, and the plutonic rocks are often eminently metalliferous; but

---

[1] Rotation alone produces electrical currents in the earth.—'Connexion of the Physical Sciences.'

mineral deposits are also abundant in rocks of sedimentary origin, especially in and near situations where these two classes of rocks are in contact with one another, or where the metamorphic structure has been induced upon the sedimentary. This is remarkably the case in Cornwall, the north of England, the Ural, and most of the great mining districts on the continent of Europe.

§ 2. **Metalliferous Deposits** are peculiar to particular rocks; tin is most plentiful in granite and the rocks lying immediately above it; gold in the Palæozoic rocks in the vicinity of porphyritic eruptions; copper is deposited in various slate formations, and in the sandstones of the trias, in certain porphyritic rocks, and in serpentine; lead is particularly abundant in the carboniferous limestone system, and is rare where there is iron and copper; iron abounds in coal and oolitic strata, and in a state of oxidised and crystallised carbonate in the plutonic and metamorphic rocks; and silver is found in almost all of these formations; its ores being frequently combined with those of other metals, especially of lead and copper. There is such a connexion between the contents of a vein and the nature of the rock in which the fissure is that, when in the oldest rocks the same vein intersects clay slate and granite, the contents of the parts enclosed in one rock differ very much from those which are found in the other. It is believed that in the strata lying above the coal measures none of the more precious metals have been found in England in such plenty as to defray the expense of raising them, although such a rule does not extend to the continent of Europe or to South America, where copper and silver ores abound in the red sandstone of the triassic series. In Great Britain no metal, except iron, is raised in any stratum newer than the magnesian limestone. Metals exist chiefly in the primary and early secondary strata, especially near the junction of granite and porphyry with slates; and it is a fact that rich veins of lead, copper, tin, &c., abound only in and near the districts which have been greatly shaken by subterraneous movements. In other countries, as Auvergne and the Pyrenees, the presence of igneous rocks may have caused mineral veins to appear in more recent strata than those which contain them in Great Britain.

§ 3. **Mines.**—When a mine is opened, a shaft like a well is generally sunk perpendicularly from the surface of the ground, and from it horizontal galleries are dug at different levels according to the direction of the metallic veins, and gunpowder and other explosives are used to blast the rocks when too hard for the pickaxe. When mines extend very far in a horizontal direction, it becomes necessary to sink more shafts, for ventilation as well as for facility in raising the ore. Such is the perfection of underground surveying in England, that the work can be carried

on at the same time from above and below so exactly as to meet; and in order to accelerate the operation the shaft is worked simultaneously from the different galleries or levels of the mine. In this manner a perpendicular shaft was sunk 204 fathoms deep, in the Consolidated mine in Cornwall; it was finished in 12 months, having been worked in 15 different points at once. In that mine some years ago there were 95 shafts, besides other perpendicular communications underground from level to level: the depth of the whole of these shafts added together amounted to about 25 m.; the galleries and levels extending horizontally about 43 m.; and 2500 persons were employed in it; yet this is but one of many mines now in operation in the mining district of Cornwall alone.[1]

The infiltration of the rain and surface water, together with subterranean springs, would soon inundate a mine, were not adequate means employed to remove it. The steam engine is often the only way of accomplishing what in many cases would otherwise be impossible, and the produce of mines has been in proportion to the successive improvements in that machine.

Mines in high ground are sometimes drained to a certain depth by an adit or gallery dug from the bottom of a shaft in a sloping direction to a neighbouring valley. One of these adits extends through the large mining district of Gwennap in Cornwall; it begins in a valley near the sea, and very little above its level, and communicates with all the neighbouring mines, which it drains to that depth, and with all its ramifications is 30 m. long. Nent Force Level, in the N. of England, forms a similar drain to the mines in Alston Moor; it is a stupendous aqueduct, 9 ft. broad, and in some places from 16 to 20 ft. high; it passes for more than 3 m. under the course of the River Nent to Nentsbury engine shaft, and is navigated underground by long narrow boats. Daylight at its mouth is seen like a star at the distance of a mile in the interior. Most of the adits admit of the passage of men and horses, with rails at the sides for waggons.

The access to deep mines, as in Cornwall, is usually by a series of perpendicular or slightly inclined ladders, sometimes uninterrupted, but generally broken at intervals by resting places. It is computed that one third of a miner's physical strength is exhausted in ascending and descending a deep mine. The man engine, which is a series of platforms fixed on a perpendicular rod worked by the steam engine, is now used in a few of the deepest mines.

The greatest depth to which man has excavated is nothing when

---

[1] J. Taylor, Esq., on 'Cornish Mines.'

compared with the radius of the earth. The Eselschacht mine at Kuttenburg in Bohemia, now inaccessible, which is 3778 ft. below the surface, is deeper than any other mine. Its depth is only 150 ft. less than the height of Vesuvius, and it is eight times greater than the height of the pyramid of Cheops, or the cathedral of Strasburg. The Monkwearmouth coal mine, near Sunderland, descends to 1500 ft. below the level of the sea, so that the barometer stands there at 31·70, which is higher than anywhere on the earth's surface.[1] The salt works of Neu-Salzwerk in Prussia are 2231 ft. deep, and 1993 ft. below the level of the sea. Mines on high ground may be very deep without extending to the sea level: that of Valenciana, near Guanaxuato in Mexico, is 1686 ft. deep, yet its bottom is 5960 ft. above the surface of the sea; and the mines in the higher Andes must be much more. For the same reason the rich mine of Joachimsthal in Bohemia, 2120 ft. deep, has not yet reached that level. The fire springs at Tseu-lieu-tsing in China are 3197 ft. deep, but their relative depth is unknown.[2] How insignificant are all the works of man compared with nature!

§ 4. **Diffusion of Metals.**—The metals are very profusely diffused over the earth. There are few countries of any extent which do not contain some of them. A small number occur pure, but in general they exist in the form of ores in which the metal is chemically combined with other substances, and they are often so mixed with earthy matter and rock that it is necessary to reduce them to a coarse powder in order to separate the metallic portion, which is rarely more than a third or fourth part of the mass brought above ground.

Gold is chiefly found in the Palæozoic strata where traversed by plutonic rocks, disseminated in veins and small threads or grains in the matrix itself; the upper part of the rocks or veins containing the metal is in general the richest, decreasing in quantity with the depth. Most of the surface gold has already been removed by natural causes; and although gold is found in almost every country it is in such minute quantities that it is often not worth the expense of working. It is almost always in a native state, and in the form of crystals, grains, or masses called nuggets. Sometimes it is combined with silver; but it is chiefly in the alluvial deposits, resulting from the destruction and disintegration of the originally auriferous rocks, that this precious metal is now procured. It is exhausted in several parts of Europe where it was formerly found. The united

---

[1] Supposing the barometer to be 30 inches on the level of the sea.

[2] Note to the English translation of 'Kosmos,' by General Sabine, on the depths below the surface of the earth attained by man.

produce of the mines in Transylvania, Hungary, the N.W. districts of Austria, and the bed of the Danube, is nearly 60,000 ounces annually. Gold is found in small quantities in Spain, Wales, Scotland, at Leadhills, and in Sutherlandshire, and in the Wicklow mountains in Ireland.

Gold abounds in Asia, especially in Siberia. The alluvial deposits at the foot of the Ural Mountains are very rich. In 1826 a piece of pure gold weighing 23 pounds was found there, along with others weighing 3 or 4 pounds each, accompanied by bones of elephants. The alluvium there is ferruginous: and more to the E., as already mentioned, a rich auriferous region as large as France has lately been discovered, resting on rocks which contain it. In 1834 the treasures in that part of the Altaï chain called the Gold Mountains were discovered, forming a mountain knot nearly as large as England, from which a great quantity of gold has been extracted. Gold is found in Tibet, in the Chinese province of Yunnan, in the mountains of the Indo-Chinese peninsula, in Japan, and in Borneo, where it occurs near the surface in several places.

Africa has long furnished a considerable supply to Europe. That part of the Kong Mountains W. of the meridian of Greenwich was one of the most auriferous regions in the world before the discoveries in California. The auriferous stratum lies from 20 to 25 ft. below the surface, and increases in richness with the depth. The gold is found in particles and pieces in a reddish sand. Most of the streams from the table-land bring down gold, as well those that descend to the low ground to the N. as those that flow to the Atlantic and the Indian Ocean, S. of Mozambique.

In South America the Western Cordillera is poor in metals except in New Granada, where the most westerly of the three chains of the Andes is rich in gold and platinum—a metal found only there, in Brazil, and on the European side of the Ural Mountains—and all in alluvial deposits. The largest piece of platinum that has been found weighed 21 ounces. Gold is found in alluvial deposits on the high plains of the Andes, on the low lands to the E. of them, and in almost all the rivers that flow on that side. The whole country between Jaen de Bracamoros and the River Guaviare is celebrated for its metallic riches. Almost all the Brazilian rivers bring down gold. The province of Minas Geraes is very rich in gold; and numerous mines, the chief of which is that of Morro Velho, are worked. The gold deposits of Minas Geraes are all the produce of primitive and metamorphic rocks, and there are three chief varieties of the gold ore—viz. quartz gold, Jacutinga (micaceous iron with free gold in lines and pot holes), and pyritic formations (magnetic iron and arsenical pyrites, in

which gold is minutely disseminated). Central America, Mexico, California, and British Columbia are auriferous countries. The quantity of gold found near the surface in California exceeded that of all other countries until the discovery of the auriferous deposits in Australia, which in the year 1856 amounted to 12,633,138*l*. Victoria, New South Wales, and Queensland, all yield large quantities of gold, and it is believed that this metal will ultimately be found in connexion with all the mountain masses of the Australian continent. Gold bearing quartz and alluvial deposits have also been found in Tasmania, at some distance from Launceston; and the diggings in both the North and Middle Islands of New Zealand have proved very valuable. In 1858, the gold fields of British Columbia were first worked. The precious metal exists in all the tributaries of the Frazer, of which more than 60 are known. The most productive gold field is that of Cariboo, lying between the Quesnelle Lake and the Upper Frazer. Gold has also been found to some extent in the S. of Vancouver Island, particularly in the valley of the Sooke River. A considerable quantity is found in Tennessee, the mountains of Georgia, and on 1000 sq. m. of N. Carolina; in fact, it is found at intervals from Canada to Georgia, and in Nova Scotia.

A great deal of *silver* is raised in Europe. The mines of Hungary are the most productive, especially those in the mountains of Chemnitz. The metalliferous mountains of the Erzegebirge are very rich, and also the mines near Christiania in Sweden. Silver is found in Saxony, Transylvania, and Austria. The lead mines of England produced, in 1873, 1,131,907*l*. worth of this metal. In no part of the old continent is silver in greater abundance than in the Ural and Altaï Mountains, especially in the district of Kolyvan. There are silver mines in Armenia, Anatolia, Tibet, China, Cochin-China, and Japan.

The richness of the Andes in silver can hardly be conceived, but the mines are frequently on such high ground that the profits are diminished by the difficulty of carriage, the expense of living in a barren country, sometimes destitute of water, where the miners suffer from cold and snow, and especially from the want of fuel. This is particularly the case at the silver mines of Copiapo in Chile where the country is utterly barren, and not a drop of water is to be found in a circuit of 9 m. These mines were discovered by a poor man in 1832, who hit upon a mass of silver in rooting out a tree. They extend over 150 square leagues. Sixteen veins of silver were found in the first four days, and before three weeks elapsed, forty more, not reckoning smaller ramifications. The rolled pieces which lay on the surface produced a large quantity of pure silver. A

single mass weighed 5000 pounds.[1] With Mexico, Chile is now the country most productive in silver.

In the mines of Copiapo the silver veins are sometimes cut off by a dyke of limestone, but on the underside of the dyke it is found richer than ever, and crowned by a mass of pure silver, varying in weight from hundreds to even thousands of marcs. It often happens that vegetation is poor where mineral riches are great, especially in the countries where silver, lead, and coal are found. It is particularly the case in Atacama, where an immense and confused mass of sand and rocks of every colour and shade has the appearance of great cities destroyed by some terrible earthquake and then discoloured by fire. Yet even here a peculiar beauty sometimes prevails. Patches and streaks having every colour of the rainbow—from the green of the most luxuriant vegetation to the most brilliant yellow and red—point out the localities of immense deposits of copper and oxides of iron. These and the varied colours of quartz and porphyritic rocks, when heightened by the tints of a setting sun, gradually subsiding from the brighter colours into rose, then purple, and lastly a fading neutral tint, in a calm, pure, and transparent atmosphere, are surpassingly beautiful.[2]

In Peru there are silver mines along the whole range of the Andes, from Caxamarca to the Desert of Atacama. The most productive at present are those of Pasco, which were discovered by an Indian in 1630. They have been worked without interruption since the beginning of the seventeenth century. The soil under the town of Pasco is metalliferous, the ores probably forming a series of beds contemporaneous with the strata. The richness of these beds is not everywhere the same, but the nests of ore are numerous. The mines of Potosi, 16,150 ft. above the sea level, are celebrated for riches, but the owners have to contend with all the difficulties which such an elevated situation imposes. The ore in the mines at Chota is near the surface over an extent of half a square league, and the filaments of silver are sometimes even entwined with the roots of the grass. This mine is 13,300 ft. above the level of the sea, and even in summer the thermometer is below the freezing point in the night. In the district of Huantajaya, not far from the shores of the Pacific, there are mines where masses of pure silver were found, of which one weighed 800 pounds.[3] A large amount of silver is found in the Great Basin W. of the Rocky Mountains, and is worked in the territory of Nevada. In 4 years, silver to the value of 11,000,000*l.* was sent out from this district alone.

---

[1] Dr. Pöppig's 'Travels in Chile and Peru.'

[2] Colonel Lloyd on the 'Mines of Copiapo.'

[3] Dr. Pöppig.

According to Humboldt, the quantity of the precious metals brought to Europe between the discovery of America and the year 1803 was worth 1,257,000,000*l.*; and the silver alone taken from the mines during that period would form a ball 89 ft. in diameter. The disturbed state of the S. American republics and the high price of quicksilver long interfered with the working of the mines, but quicksilver is now obtained in California.

Lead Ore is very often combined with silver, and is then called Argentiferous Galena. It is one of the principal productions of the British mines, especially in the northern mining district, which occupies 400 sq. m. at the junction of Northumberland, Cumberland, Westmoreland, Durham, and Yorkshire. It comprises Alston Moor, the mountain ridge of Crossfell, and the dales of Derwent, East and West Allendale, the Wear, the Tees. There are other extensive mining tracts separated from this by cultivated ground. The principal products of this rich district are lead and copper. The lead mines lie chiefly in the upper dales of the Tyne, Wear, and Tees, and most of the ore contains a proportion of silver, though not always enough to indemnify the expense of refining or separating the silver. The deleterious vapours resulting from this process are conveyed in a tube along the surface of the ground for 14 m.; and instead of being, as formerly, a dead loss to the proprietor, they are condensed in their passage, and in one instance yielded metal to the annual value of 10,000*l.*[1] The total amount of lead produced from the mines of the United Kingdom alone, in 1876, was 73,500 tons, and of silver from their argentiferous galenas 375,707 ounces.

Lead mines are worked in France but not to any great extent; those of the S. of Spain furnish large quantities of this metal; also in Saxony, Bohemia, and Carinthia, where they are very rich. Lead is not very frequently found in Siberia, though it does occur in the Nertchinsk mining district, in the basin of the River Amur. It is also a production of Japan, of China, of the peninsula beyond the Ganges, of Lower Peru, Mexico, and California. But the most extensive lead mines known in the world are in North America. They lie on both sides of the Upper Mississippi, and generally throughout the western section of the United States as well as in the States on the Atlantic. They are extensively worked, and were more so before the discovery of gold in California. The lead mines in the valley of the Upper Mississippi are of truly wonderful extent, spreading over an area of 3600 sq. m. and the metal lies near the surface.

Quicksilver—a metal so important in separating silver from its

[1] Constructed under the direction of Thomas Sopwith, Esq.

ores, and in various arts and manufactures as well as in medicine—occurs either liquid in the native state or combined with sulphur in that of cinnabar. It is found in the mines of Idria and some other places in the Austrian empire, in the Palatinate on the left bank of the Rhine, in several parts of Tuscany, and in Spain. The richest quicksilver mines of Europe at the present day are those of Almaden, where the quicksilver is found in the state of sulphuret chiefly disseminated in the Silurian strata. These mines were worked 700 years before the Christian era, and as many as 1200 tons of the metal are extracted annually. It occurs in China, Japan, and Ceylon, at San Onofrio in Mexico, and in Peru at Huancavelica, the mines of which, now almost abandoned, produced up to the beginning of the present century the enormous quantity of 54,000 tons of quicksilver. There is a mine of quicksilver, probably unrivalled in richness, 20 m. from San José, in the Clara valley of California, and three or four of cinnabar, the sulphuret of mercury, which were known to the Indians, who used the cinnabar to paint themselves. At one time there were more than two millions of pounds in weight of ore lying at the mouth of the mine, from whence it is carried in skin sacks on the shoulders of men. It is supposed that this ore will produce 50 per cent. of pure quicksilver.

Copper is of such common occurrence that it would be vain to enumerate the localities where it is found. It is produced in Africa, Persia, India, China, and Japan. The copper mines in the United States of North America are probably the richest and most extensive in the world, especially those of Lake Superior, where masses of 50 tons weight of pure copper have been found, and in the Cleff mine even of 60 or 80 tons, and a stratum of pure copper 3 ft. thick has been cut through. Copper as rich as any on Lake Superior is found in Queensland and in the interior of Australia. The Siberian mines are very productive both in ore and native copper. The choicest specimens of malachite, the most beautiful of its ores, come from Siberia. Almost every country in Europe yields copper. The mines in Sweden, Norway, and Germany are very productive; and it forms a principal part of our own mineral wealth. It is raised in all the chief mining districts in England and Wales. In Cornwall and Devon, where they are often associated with tin, its ores produced 10,233 tons of pure metal in 1867. The period at which the Cornish mines were first worked goes far beyond history, or even tradition: certain, however, it is that the Phœnicians came to Britain for tin. Probably copper was also worked very early in small quantities, for its exportation was forbidden in the time of Henry VIII. It was only in the beginning of the 18th century that the Cornish copper mines were

worked with success, by aid of the steam engine and of an improved machine for draining them.[1]

In Cornwall and Devonshire clay slate rests upon granite and is traversed by porphyritic dykes. The veins which contain copper or tin, or both, run E. and W., and penetrate both the granite and the clay slate. The non-metalliferous veins run N. and S.; and if veins in that direction do contain any metal, it is never tin or copper, but lead, silver, cobalt, or antimony, which with little exception are believed to be always in the clay slate. No miner in Cornwall has ever seen the end or bottom of a vein; their width varies from the thickness of a sheet of paper to 30 ft.; the average is from 1 to 3 ft. It rarely happens that either tin or copper is found nearer the surface than 80 or 100 ft. If tin be first discovered, it sometimes disappears after sinking the mine 100 ft. deeper, when copper is found, and in some instances tin is found 1000 ft. deep without a trace of copper; but if copper is first discovered, it is very rarely succeeded by tin. Tin is found in rolled pieces, in alluvial beds of sand and gravel, and is then called stream tin. With the exception of the Indian Archipelago, of all countries England is the most productive in tin ores, which in 1867 gave 8700 tons of the pure metal. The most valuable tin mines on the continent of Europe are those in Saxony; it also occurs in France, Bohemia, and Spain. One of the richest deposits of tin known is in the province of Tenasserim, on the E. side of the Gulf of Martaban, in the Malayan peninsula. These deposits occur in several parts of that country; the richest is a layer 8 or 10 ft. thick of sand and gravel, in which masses of oxide of tin are sometimes the size of a pigeon's egg. The best of all comes from the Island of Banca, at the extremity of the peninsula of Malacca; a large portion of it is imported into Britain, and much goes to China. It is found in the alluvial tracts throughout all parts of the island, rarely more than 25 ft. below the surface. The whole tin field extends at intervals over 17 degrees of latitude, and its produce is double that of Cornwall. Great deposits occur also in the Siberian mining district of Nertchinsk, near the Desert of Gobi, and near Oruro in Bolivia; and stream tin has been recently discovered in the auriferous deposits of South Australia.

There are comparatively few *Coal Mines* worked within the tropics; they are mostly in the temperate zones, especially between the Arctic Circle and the Tropic of Cancer; and as iron, the most useful of metals, is chiefly found in the carboniferous strata, it follows the same distribution. In fact, the most productive iron mines yet known are in the temperate zones. In the

[1] Sir Charles Lemon, Bart.

eastern mining district of Siberia, in the valley of the River Vilui, the ores are very rich, and very abundant in many parts of the Altaï and Ural. In the latter the mountain of Blagod, at 1534 ft. above the sea, is one mass of magnetic iron ore.[1] Coal and iron are worked in so many parts of Northern China, Japan, India, and Eastern Asia, that it would be tedious to enumerate them.

In Europe the richest mines of *iron*, like those of coal, lie chiefly N. of the Alps. Sweden, Norway, Russia, Germany, Styria, Belgium, and France, all contain it plentifully. In Britain many of the coal fields contain subordinate beds of a rich argillaceous iron ore, interstratified with coal, worked at the same time and in the same manner; besides, there is a substratum of limestone, which serves as a flux for melting the metal. The principal mines lie round Birmingham, in the Staffordshire coal field, in the great coal basin of South Wales about Pontypool and Merthyr Tydvil, and in Scotland about Glasgow. There are extensive iron mines in Staffordshire, Shropshire, North and South Wales, Yorkshire, and Derbyshire. It would be impossible to state the number of mines which yield iron sufficient for our own enormous consumption and for exportation; but an idea may be formed of their extent when it is stated that in 1873 they furnished 15,577,499 tons of ore, which yielded 6,566,451 tons of pig iron, valued at 18,057,739*l.* sterling.

§ 5. **Coal Mines.**—These productive iron mines would have been of no avail had it not been for the abundance of fuel with which the greater part of them in the N. of England, Scotland, and Wales are associated—the great source of our national wealth, more precious than mines of gold. Most of the coal mines would have been inaccessible but for the means which their produce affords of draining them at a small expense. A bushel of coals, which costs only a few pence, generates in the furnace of a steam engine a power which in a few minutes will raise 20,000 gallons of water from a depth of 360 ft.—an effect which could not be accomplished in a shorter time than a whole day by the continuous labour of 20 men working with the common pump. Yet this circumstance, so far from lessening the demand for human labour, has caused a greater number of men to be employed in the mines.

The coal strata lie in basins, dipping from the sides towards the centre, which is often at a vast depth below the surface of the ground. The centre of the Liége coal basin is 21,358 ft., or 4 m., deep, which is easily estimated from the dip or inclination of the

[1] M. Erman's 'Travels in Siberia.'

strata at the edges, and the extent of the basin. The coal lies in strata of small thickness and great extent. It varies in thickness from 3 to 9 ft., though in some instances several layers come together, and then it is 20, and even 30, ft. thick; but these layers are interrupted by frequent dislocations, which raise the coal seam towards the surface. These fissures, which divide the coal field into insulated masses, are filled with clay, so that an accumulation of water takes place which must be pumped up.

There are 14 coal fields in the United Kingdom: in 1873 the produce of these amounted to 127,000,000 tons. Should the produce continue at that rate, it has been computed that this coal area will be exhausted in less than 1000 years unless means be discovered of working to a greater depth than 2000 ft., the obstacles being the creep or slow tendency of the roof and floor of the mine to meet from the increased pressure, and the want of more effectual ventilation to overcome the increase of the earth's temperature; probably both will be overcome.

The splendid discovery of Sir Humphry Davy, that flame does not pass through fine wire gauze, prevents the fatal explosion of inflammable air in the mines, by which thousands of lives have been lost. By means of a light enclosed in a wire gauze lantern, a miner now works with safety surrounded by fire damp. To the honour of the illustrious author of this discovery, be it observed that it was not, like that of gunpowder and others, the unforeseen result of chance by new combinations of matter, but the solution of a question based on scientific experiment and induction, which it required the genius of a philosophic mind like Davy's to arrive at. However, it is now doubted whether Davy's lamp is a protection on all occasions; yet it never fails to give warning of danger by the manner in which it burns.

The Scotch coal field is a most important one, and occupies the great central low land of Scotland, lying between the southern high lands and the Highland mountains; the whole of that wide tract is occupied by it, besides which there are others of less extent. In 1867 the Scotch collieries produced 14,125,943 tons from 485 collieries. Coal has been found in 17 counties in Ireland, but the principal coal districts taken together only produce from 145,000 to 165,000 tons.

Thus there is coal enough in the British Islands to last more than a thousand years; and were it exhausted, our friends across the Atlantic have enough to supply the world for ages uncountable.[1]

[1] In the year 1873 the value of the mineral product of Great Britain was as follows, namely—

The carboniferous strata are enormously developed in the States of North America. The Appalachian coal field extends without interruption 720 m., with a maximum breadth of 280 m., from the northern border of Pennsylvania to near Huntsville, in Alabama, occupying an area of 63,000 sq. m. It is intersected by three great navigable rivers—the Monongahela, the Alleghany, and the Ohio—which expose to view the seams of coal on their banks. The Pittsburg seam, 10 ft. thick, exposed on the banks of the Monongahela, extends horizontally 225 m. in length and 100 in breadth, and covers an area of 14,000 sq. m., so that this seam of coal may be worked for ages almost on the surface, and in many places literally so. Indeed, the facility is so great that it is more profitable to convey the coal by water to New Orleans, 1100 m. distant, than to cut down the fuel, which may be had for the expense of felling. The coal is bituminous, similar to the greater part of the British coal; 40 m. to the E., however, among the ridges of the Appalachian chain, there is an extensive outlying member of the great coal field which yields *Anthracite*, a species of coal which burns without smoke.

In the Western States, the Illinois coal field which occupies part of Illinois, Indiana, and Kentucky, is as large as England, and consists of horizontal strata, with numerous seams of rich bituminous coal. There is a vast coal field also in Michigan. Large areas in New Brunswick and Nova Scotia abound in coal, and good coal is worked at Nanaimo in Vancouver Island; 150 to 300 tons daily were taken out in 1867, near the Red River, and various

---

	£
Minerals	59,479,486
Metals	21,409,878
Total . . .	£80,889,364

At present there are upwards of 127,000,000 of tons of coals raised in Great Britain annually, including the quantity exported to our colonies and to foreign countries, amounting to upwards of 12,000,000 tons.

The iron made in Britain in 1873 amounted to 6,566,451 tons.

The produce of our copper mines in 1873 amounted to 5,240 tons of pure metal. The quantity of tin was 9,972 tons in 1873.

2,393,991 tons of British coal were imported into France in 1873.

Belgium is next in importance to England as a coal producing country. In Britain the coal fields occupy one twentieth part of the area of the country—in Belgium one twenty second part—in France one two hundred and tenth part of its area.

The quantity of coal raised in 1871 was—

In Belgium	13,733,176 tons.
„ Germany	37,000,000 „

other parts of British America. Iron is worked in many parts of the United States from Connecticut to South Carolina.[1]

The tropical regions of the globe have been so little explored that no idea can be formed of the quantity of coal or iron they contain; but as iron is so universal it is probable that coal is not wanting. It is found in Formosa. Both abound in Borneo, and in various parts of tropical Africa and America. There is comparatively so little land in the S. temperate zone, that the mineral produce must necessarily be more limited than in the N., yet Australia, Tasmania, and New Zealand are rich in coal and iron.

§ 6. **Arsenic and other Metals:—Salt; Sulphur.**—*Arsenic*, used in the arts and manufactures, is generally found combined with iron and sulphur in many countries as well as our own. Manganese, zinc, bismuth, and antimony are raised to a considerable amount. As the qualities of the greater part of the more rare metals are little known, they have hitherto been interesting chiefly to the mineralogist and chemist.

The mines of *Rock Salt* in Cheshire seem to be inexhaustible. Enormous deposits of salt extend 600 m. on each side of the Carpathian Mountains, and throughout wide districts in Austria, Galicia, Tuscany, and Spain. It would not be easy to enumerate the places in Asia where rock salt has been found. Armenia, Syria, extensive tracts in the Punjab, China, and the Ural district, abound in it; and the Andes contain vast deposits, some of which are at great heights.

Volcanic countries in both continents yield *Sulphur*. Italy and Sicily, where it is in the tertiary marine strata, are the magazines whence the chief supplies of Europe are drawn. It is often beautifully crystallised. *Asphalt*, *Nitre*, and *Alum* are found in various parts of Europe and Asia; *Natron* is procured from small lakes in an oasis on the W. of the Valley of the Nile; *Nitrate of Soda*, now extensively used in agriculture and in chemical manufactures, in the Desert of Tarapaca in Peru; and *Naphtha*, or *Petroleum*, in immense quantities, in Canada and the United States. Petroleum is also found in Wallachia, and in small quantities in Derbyshire. The petroleum obtained from America must be distinguished from the paraffin and other mineral oils procured by the destructive distillation of coal and bituminous shale in England and Scotland.

§ 7. **Diffusion of Gems.**—The diffusion of *Precious Stones* is very limited. *Diamonds* are found in a soil of sand and gravel, and in the beds of rivers. Brazil furnishes most of the diamonds of commerce; they are the produce of tracts on each side of the

[1] Sir Charles Lyell's 'Travels in the United States of North America.'

Serra Espinhaço, and of a district watered by some of the affluents of the Rio São Francisco. During the century ending in 1822, diamonds were collected in Brazil to the value of 3,000,000*l*., one of which weighed 138½ carats. In 1853, a diamond weighing 254½ carats in its rough state was found by a negress in the Province of Minas Geraes. It is called the 'Star of the South,' and was shown at the Great Exhibition in London in 1862. The celebrated mines of Golconda have produced many splendid diamonds: they are also found in Borneo, which produced one weighing 367 carats, valued at 269,378*l*. The eastern parts of the Tian Shan and a wide district of the Ural Mountains yield diamonds, and they are now found in the basin of the Orange River in South Africa.

The *Ruby* and *Sapphire*, which have the same crystalline form, are found in Ceylon in the gravel of streams. The rubies at Gharan, near to the River Oxus, are embedded in limestone. The gravel of rivulets in the Birman empire contains the oriental star, and opalescent rubies. The *Spinelle* also occurs in that country in a district five days' journey from Ava. The blue, green, yellow, and white sapphires are the produce of the Birman empire.

The finest *Emeralds* come from veins in a blue slate, of the age of our lower chalk strata, in the valley of Muzo in New Granada.[1] *Beryls* are found in Brazil, and in the old mines in Mount Zebarah in Upper Egypt. Those of Hungary and of the Heubach Valley near Salzburg are very inferior in colour and quality.

Mexico, Hungary, and Bohemia yield the finest *Opals*; the most esteemed are opaque, of a pale brown, and shine with the most brilliant iridescence; some are white, transparent, or semi-transparent, and radiant in colours. The most beautiful *Garnets* come from Bohemia and Hungary, where they are found in the Harz Mountains. They occur also in Ceylon, and in many other localities. The *Turquoise* is a Persian gem, of which there are two varieties; one is supposed to be the enamel of the tooth of a fossilised mastodon, the other a purely mineral substance. Badakshan is the principal locality of the *Lapis Lazuli*. This beautiful mineral is also found in several places of the Hindu Kush, in the hills of Istalif, N. of Cabul, in Tibet, and in the Baïkal Mountains in Siberia.

The *Cat's-eye* is peculiar to Ceylon. *Topazes*, *Beryls*, and *Amethysts* are of very common occurrence, especially in Brazil and Siberia. They are little valued, and scarcely accounted gems.

---

[1] This curious geological fact has been established by the discoveries of Professor Lewy, who has sent to Paris specimens in which crystals of emerald and greensand fossils are embedded.

Agates are so beautiful on the table-land of Tibet, and in some parts of the Desert of Gobi, that they form a considerable article of commerce with China; and some are brought to Rome, where they are cut into cameos and intaglios. But the greater part of the *Agates*, *Carnelians*, and *Chalcedonies* used in Europe are found in the trap rocks round Oberstein in the Palatinate.

Thus, by her unseen ministers, electricity and reciprocal action, the great artificer Nature has adorned the depths of the earth and the heart of the mountains with her most admirable works, filling the veins with metals, and building the atoms of matter with the most elegant and delicate symmetry, into innumerable crystalline forms of inimitable grace and beauty. The calm and still exterior of the earth gives no indication of the activity that prevails in its bosom, where treasures are preparing to enrich future generations of man. Gold will be sought for, and the diamond will be gathered among the débris of the mountains while time endures.

CHAPTER XVIII.

THE OCEAN.

§ 1. **Extent of the Ocean; Variation in Depth; its Colour and Pressure.**—The ocean, which fills a deep cavity in the globe, and covers three fourths of its surface, is so unequally distributed that there is three times more land in the northern than in the southern hemisphere. The torrid zone is chiefly occupied by sea, and only a thirteenth part of the land on one side of the earth has land opposite to it on the other. The form assumed by this immense mass of water is that of a spheroid flattened at the poles; and as its mean level is supposed to be nearly the same, it serves as a base to which all heights of land are referred.

The ocean is continually receiving the spoils of the land. From that cause it would constantly be decreasing in depth, and as the quantity of water is always the same its superficial extent would increase. There are, however, counteracting causes to check this tendency: the secular elevation of the land over extensive tracts in many parts of the world is one of the most important. Volcanoes, coral islands, and barrier reefs, show that great changes of level are constantly taking place in the bed of the ocean itself—that symmetrical bands of subsidence and elevation extend alternately over an area equal to a hemisphere, from which it may be concluded that the balance is always maintained between the sea

and the land, although the distribution may vary in the lapse of time.[1]

The Pacific, or *Great Ocean*, exceeds in superficies all the dry land on the globe. It has an estimated area of 67,810,000 sq. m.; including the Indian Ocean, its area is nearly 97,000,000, and its breadth, from Peru to the coast of Africa, is 12,000 m. Its length is above 9000 m. It communicates with the Arctic Ocean by Behring Strait.

The continent of Australia occupies a comparatively small portion of the Pacific, while innumerable islands stud its surface many degrees on either side of the equator, of which a great number are volcanic, showing that its bed has been, and indeed actually is, the theatre of violent igneous eruptions. The deepest soundings which have yet been taken of this ocean are one of 4575 fathoms (above 5 m.) made by the 'Challenger,' March 23, 1875: one of 4643 fathoms ($5\frac{1}{4}$ m.), and one of 4655 fathoms (more than $5\frac{1}{4}$ m.) taken by the 'Tuscarora' off the E. coast of Japan. Yet as the whole mass of the ocean counts for little in the total amount of terrestrial gravitation, its mean depth, probably about 2500 fathoms (nearly 3 m.), is but a small fraction of the radius of the globe. The Pacific is the calmest of oceans; its tides are low, and its great currents broad and sluggish.

The bed of the *Atlantic* is a long deep valley, separating two vast continents, and probably extending from pole to pole. Its greatest breadth, including the Gulf of Mexico, is 5000 m.; its superficial extent is estimated at upwards of 35,000,000 sq. m. It is probably the most stormy of all the seas; its tides are high, and its principal currents narrow and swift. The bed of the S. Atlantic has been sounded by vessels in the British Naval Survey, and bottom has been found between the Cape of Good Hope and Ascension Island, at depths varying from 10,800 to 17,400 ft.; nearer the equator between 24° and 25° W. long. the bed is much deeper, bottom being touched at 19,200 and 19,500 ft., and in mid ocean on the parallel of 28° S., the depth was found to be 18,600 ft. The great difficulties attendant on sounding vast depths of ocean have been overcome by Brooke's deep sea sounding apparatus, which enabled the officers of the United States navy to make an extensive and accurate survey of the N. Atlantic. The soundings made by the 'Challenger' in her recent voyage (1873–1876) were made with a further improved apparatus. The greatest depth that the sounding lead has reached in the N. Atlantic is nearly 90 m. N. of St. Thomas's (W. Indies), where the 'Challenger' found

[1] Mr. Alfred Taylor has computed that all existing causes would produce an elevation of only three inches in 10,000 years.

3975 fathoms (above 4½ m.). Hence from the top of Mount Everest, in the Himalaya, the highest ascertained point on the globe, to the deepest point of soundings is nearly 10 m., estimated in a vertical line.

Throughout the N. Atlantic the land shelves down to greater and greater depths gradually on both sides. On the coast of North America these submarine terraces seem to have a very regular and marked outline, the water increasing on them successively, leaving in the central parts the deepest portion. An extensive plateau of moderate depth extends from Newfoundland to the south of Ireland. Between Trinity Bay, in Newfoundland, and Valentia Island, Ireland, are laid the Telegraph Cables of 1865 and 1866. In its deepest part the ocean bed on this plateau does not descend more than 14,544 ft.; while in many parts it is not deeper than 9000 or 10,000 ft. Such is the Telegraphic Plateau. On it are laid those stupendous cables which form part of the boldest and noblest results of science. The subject of deep sea sounding, and, in short, all that relates to what has been termed the Physical Geography of the Sea is undergoing rapid development. The early statements regarding unfathomable depths of ocean are to be received with much caution, as many of them have been disproved by actual experiment; thus in the very area, S. of the bank of Newfoundland, where the greatest depth of the N. Atlantic was supposed to exist, Commander Chimmo, of H.M.S. 'Gannet,' found, in 1868, bottom at 8700 ft. The question of the existence of living animals at great depths receives illustration from these surveys, and it is now believed that the beautiful little organisms called *Radiolarians* live all through the sea and down to its greatest depths.[1]

Immense banks rise from great depths to within a few fathoms of the surface of the ocean. Of these the Agulhas Banks, off the Cape of Good Hope, are among the most remarkable. But the double bank of Newfoundland is of still greater extent: it seems to have been formed by drift brought by an under current from the Arctic Ocean, as the water becomes suddenly deep at the southern extremity. The Dogger Bank, in the North Sea, and many others are well known. According to Mr. Stevenson, one fifth of the North Sea, an area equal to that of Great Britain, is occupied by banks whose average height is 78 ft. On that account the average depth is only 96 ft. Some of these elevations near the coast of Norway are surrounded by such deep water that they must be submarine table-lands. By soundings during the coast survey of the United Kingdom it appears that Great Britain,

[1] See Sir C. Wyville Thomson's 'Address at the Glasgow Meeting of the British Association,' 1876.

Ireland, and the innumerable islands and rocks that rise above the surface of the sea, repose upon a submarine bank bounded by a line 100 fathoms deep, and this bank is connected on the S.E. through Holland and Belgium with the continent of Europe, while it is separated from Norway and Sweden by a very deep channel. Some of the deepest wells in London and Sheerness draw their fresh water from a stratum which lies fully 300 ft. below the surface of the submarine bank that intervenes between Britain and the coasts of Belgium, Holland, and Denmark.[1] Currents are sometimes deflected from their course by banks whose tops do not come within 50 or even 100 ft. of the surface. Where banks or reefs rise to the surface in tropical seas, cocoa nut palms have been planted by some of our cruisers to give warning of danger; as, for example, on a dangerous shoal off the coast of Brazil, called Las Roccas, lying about 120 m. W. of Tristan da Cunha.

The pressure at great depths is enormous. In the Arctic Ocean, where the specific gravity of the water is somewhat lessened, on account of the greater proportion of fresh water produced by the melting of the ice, the pressure at the depth of a mile and a quarter is 2809 pounds on a square inch of surface; this was confirmed by Captain Scoresby, who says, in his 'Arctic Voyages,' that the wood of a boat suddenly dragged to a great depth by a whale was found, when drawn up, so saturated with water forced into its pores that it sank in water like a stone for a year afterwards. So enormous was the pressure in the deep sounding (3975 fathoms) made by the 'Challenger' near St. Thomas's Island, that the bulbs of the thermometer, which had been made to stand a pressure of nearly 3 tons, were broken. The compression that a whale can endure is wonderful. Many species of fish are capable of sustaining great as well as sudden changes of pressure. Divers in the pearl fisheries exert great muscular strength, but man cannot bear the increased pressure at great depths, because his lungs are filled with air, nor can he endure the diminution of it at great altitudes above the earth.

The depth to which the sun's light penetrates the ocean depends upon the transparency of the water, and cannot be less than twice the depth to which a person can see from the surface. In parts of the Arctic Ocean, in the Caribbean Sea, and elsewhere shells may be distinctly seen at the depth of 120 fathoms; and among the West India Islands, in 80 fathoms water the bed of the sea is as clear as if seen in air; shells, corals, and seaweeds of every hue display the tints of the rainbow.[2]

---

[1] Sir R. Murchison's 'Address,' May 24, 1858.

[2] During the deep sea dredging off the Atlantic coast of Ireland in 1869 innumerable instances of mollusca, crustacea, and other animals brilliantly

The purest spring is not more limpid than the water of the ocean; it absorbs all the prismatic colours, except that of ultramarine, which being reflected in every direction imparts a hue approaching the azure of the sky. The depth of the blue depends upon the quantity of salt contained in the water. In salt works the brine assumes a deeper blue the longer the evaporation is continued: that is the reason of the deep azure of the Mediterranean, the Gulf Stream, and the sea in the region of the trade winds. In the Indian Ocean the colour is so intense that it has been poetically called the Black Waters. The light green of the North Sea and other polar waters is owing to the lesser proportion of salt.[1] The colour of the sea varies with every gleam of sunshine or passing cloud, although its true tint is always the same when seen sheltered from atmospheric influence. The reflection of a boat on the shady side is often of the clearest blue, while the surface of the water exposed to the sun is as bright as burnished gold. The waters of the ocean also derive their colour from animalculæ of the infusorial kind, vegetable substances, and minute particles of matter. It is white in the Gulf of Guinea; off California the Vermilion Sea is so called on account of the red colour of the infusoria it contains; the same red colour was observed by Magellan near the mouth of the River Plate. The Persian Gulf is called the Green Sea by Eastern geographers, and there is a strip of green water off the Arabian coast so distinct that a ship has been seen in green and blue water at the same time. Rapid transitions take place in the Arctic Sea, from ultramarine to olive green, from purity to opacity. These appearances are not delusive, but constant as to place and colour; the green is produced partly by its freshness, as well as by myriads of minute insects, which devour one another and are a prey of larger animals. The colour of clear shallow water depends upon that of its bed; over chalk or white sand it is apple green, over yellow sand, dark green, brown or black over dark ground, and grey over mud.

§ 2. **Saltness of the Ocean: its Point of Congelation.**—The sea is supposed to have acquired its saline principle when the globe was in the act of subsiding from a gaseous state, for the water as well as the saline matter it contains is volatile and gaseous at high temperatures. The *density* of sea water depends upon the quantity of saline matter it contains.[2] Commander Maury has

coloured and with perfectly organised eyes, brought up from depths of 1230 and 1440 fathoms, give reason to believe that the bed of the ocean is not without light even at these profound depths.—*J. Gwyn Jeffreys, Esq.*

[1] Maury.

[2] According to Messrs. Schlagintweit the mean specific gravity of the surface water of the Atlantic is 1·0277, and of the Pacific 1·0265, between

computed, taking the average saltness at $3\frac{1}{2}$ per cent., and the mean depth of the sea at 2 m., that the quantity of saline matter contained in the ocean would cover an area of 7,000,000 sq. m. to the depth of 1 m., a quantity that could not have been brought from the land by rivers and floods. The constituents of sea water are everywhere the same, in consequence of the universal system of currents which prevails in the ocean, by which the mass of waters is continually mixed. The differences depend upon local circumstances, especially upon evaporation. Thus the ocean contains more salt in the southern than in the northern hemisphere, which is supposed to arise from the S.E. trade winds blowing over a greater expanse of water than the N.E., and causing a greater evaporation. The greatest proportion of salt in the waters of the Pacific is between 22° or 20° N. lat. and 17° S. lat., the regions of the trade winds; while near the equator, where these winds neutralise one another, it is less; and in the polar oceans it is the least, from the melting of the ice. The saltness varies in these regions with the seasons; the fresh water, being lightest, is uppermost. For the same reason rain makes the surface of the sea fresher than it is below, and the influx of rivers renders the ocean less salt near their estuaries. The Amazon makes the Atlantic brackish 300 m. from its mouth. The saltness of inland seas depends upon the quantity of fresh water they receive and the amount of evaporation. The Baltic is very fresh, because it has a limited evaporation at its surface, and receives many rivers. Though the Mediterranean receives large rivers, it is very salt from great evaporation; and the Red Sea, in a rainless region with great evaporation and no rivers, contains more salt than any other.[1]

Fresh water freezes at the temperature of 32° Fahr.; the point of congelation of salt water is much lower. As the specific gravity of the water of the Greenland Sea is about 1·02664, it does not freeze till its temperature is reduced to $28\frac{1}{2}$° Fahr., so that the saline principle preserves the sea in a liquid state to a much higher latitude than if it had been fresh,[2] while it is better suited for navigation by its greater buoyancy. The healthfulness of the sea is ascribed to the mixing of the water by tides and currents, which prevents the accumulation of putrescent matter.

10° and 40° S.; and 1·02613 between 40° and 60°. The weight of a cubic foot of Atlantic water is 64·003 pounds.

[1] The solid contents of sea water amount to about $3\frac{1}{2}$ per cent. of its weight: 28 elementary substances have been detected in it; but the *characteristic* ingredients of sea water are common salt, sulphates of lime, sodium, bromide, and chloride of magnesium, magnesia, potash.

[2] Fresh water acquires its maximum density at 39°·2, salt water (of the average saltness of the sea) at 27°·2.

Besides its saline ingredients, the sea contains bromine and iodine in very minute quantities, and no doubt portions of other substances too small to be detected by chemical analysis, since it has constantly received the débris of the land and all its organised matter.

§ 3. **Causes of Tides.**—The tides which flow and ebb twice a day on our coasts are raised by the combined action of the sun and moon. The water immediately under the moon is drawn from the earth by her attraction, at the same time that she draws the earth from the water diametrically opposite, in both cases producing a tide of nearly equal height. A similar action of the sun raises a wave, which, on account of his great distance, is very much less than that raised by the moon. The two waves sometimes unite, and sometimes are opposed to one another, according to the position of the luminaries; but the combined wave tends to follow the sun and moon as far as the rotation of the earth will allow, and extends to the very bottom of the sea. Being thus chiefly regulated by the moon, the tides happen twice in 24 hours, because in that time the rotation of the earth brings the same point of the ocean twice under the meridian of the moon—once under the upper meridian and once under the lower. It is clear that the highest or spring tides must happen at new and full moon, consequently twice in each lunar month, because in both cases the sun and moon are in the same meridian; for when the moon is new, they are in conjunction, and when she is full, they are in opposition, and in each of these positions their attraction is combined to raise the water to its greatest height; while, on the contrary, the neap or lowest tides happen when the moon is in quadrature, or 90° distant from the sun, for then they counteract each other's attraction.

Had the globe been entirely covered with water, the greatest tides would have taken place when the action of the sun and moon was in the plane of the equator and in the same meridian, for then their action would have been most direct; but in that case there would have been very small tides in the high latitudes and none at the poles, because then the action of the luminaries would decrease as the square of the cosine of their declination. That, however, is by no means the state of the tides, for, since the action of the sun and moon is only sensible in a vast extent of deep water, the Antarctic Ocean is their source and birthplace. The greatest spring tides, therefore, take place when the luminaries, in conjunction or opposition, are at their greatest southern declination, and the moon in perigee, that is, in the point of her orbit nearest to the earth.

When the sun and moon, under these circumstances, pass over the ocean to the E. of Tasmania, New Zealand, and the South Pole, they raise a vast ridge of water, or great tidal wave, which reaches

to the very bottom of the sea and tends to follow the luminaries to the N.W., and, having received that primitive impulse, it continues to move in that direction long after the sun and moon cease to act upon it.

On entering the Pacific, it flows along the western coast of South America, bringing high water to each place as it passes: but it is so much impeded by the numerous islands in that ocean that it is scarcely perceptible in many places among them, whereas in the Indian Ocean it rushes with such violence and speed along the shores of the Indian peninsula that it arrives at Cape Comorin before noon of the first day of its existence, nearly at the same time that it has brought high water to the coast of Tasmania.

When this tidal wave enters the Atlantic in its N.W. course, it brings high water later and later to each place; but its velocity is so very different on the two sides of that ocean that it arrives at Cape Blanco, on the W. coast of Africa, and at Newfoundland, on the E. coast of North America, at the end of the first 24 hours of its existence. It is then deflected to the E. by the continent of America, and thus, flowing at right angles to its former path, it comes to the most westerly points of Ireland and England on the morning of the second day. The great branch of this tidal wave then passes N.E. through St. George's Channel and the Irish Sea, and meeting a branch coming round the W. coast of Ireland, the united wave, after having carried high water to the W. coast of England and all the coasts of Ireland, turns round the most northern point of Scotland, and arrives at Aberdeen at noon on the second day, at the same time carrying high water to the opposite shores of Norway and Denmark. Now this tidal wave flows to the E. of S., a direction exactly contrary to that with which it began its transit through the Atlantic, and it continues this course, ruling the tides along the English shores and those of the opposite continental coasts, till it arrives at the mouth of the Thames at midnight of the second day, and does not bring high water to London till the morning of the third day after leaving the Antarctic Ocean.

The tidal wave moves uniformly and with great velocity in deep water, variably and slowly in shallow water. For example, it moves at the rate of 1000 m. an hour in the S. Pacific, and scarcely less in the Atlantic, on account of the deep trough which runs through the middle of that ocean; but the sea is so shallow on the British coasts that the tide takes more time in coming from Aberdeen to London than to travel over an arc of 120°—that is, from 60° S. lat. to 60° N. lat.

There is such a numerical relation between the breadth and velocity of a wave and the depth of the water that, if the former

be known, the depth may be computed. For example, if a wave moving at the rate of 12·21 m. in an hour be 1000 ft. broad, the depth of the sea would be 10 ft. by Mr. Airy's formula; but if a wave of the same breadth be moving at the rate of 48·77 m., the sea would be 1000 ft. deep. According to this law the S. Pacific must be of great depth.

The tide in the open ocean is merely an alternate rise and fall of the water, so that the wave travels, but not the water. A bird resting on the surface is not carried forward as the waves rise and fall; indeed, if so heavy a body as water were to move at the rate of 1000 m. in an hour, it would cause universal destruction, since in the most violent hurricanes the velocity of the wind scarcely exceeds 100 m. in an hour.

During the passage of the wave in deep water, the particles of the fluid for the moment glide into a new arrangement, and then return to their places; but this motion is extremely limited. In the ocean the resistance of the bottom is imperceptible; but in shallow water, where the velocity of the wave is small, its lower parts are more retarded than those above, and, as the friction continually increases with the progress of the wave, its top advances more rapidly than the water below, so that over shallows and near the land both water and waves advance during the flow of the tide and roll on the beach.

The height to which the tides rise depends upon the form of the shores and bottom of the sea and the direction in which the wave strikes the land. Throughout the Atlantic the height is 10 or 12 ft.; but the tidal wave rushes so directly into the Bay of Fundy that it rises to 50 ft., and from the shelving shores in the Bristol Channel it is 40 ft. When the tide enters the North Sea, to the N. of Scotland, its height is 12 ft.; but in travelling S. along the E. coast of England over a continually shelving shore, and striking the land always more directly, the water rises higher and higher at each place till in the Humber it attains 20 ft.

It sometimes happens that two equal tides coming different ways meet, and then the water rises to double the height it would otherwise have done. A complete extinction of the tide takes place when a high water interferes in the same manner with a low water, as in the centre of the North Sea; a circumstance predicted by theory and confirmed by Captain Hewett, who was not aware that such an interference existed. When two unequal tides in contrary places meet, the greater overpowers the less, and the resulting height is equal to their difference, which is supposed to be the case at Yarmouth where the tide is very small. These varieties occur chiefly in channels among islands and in the estuaries of rivers. When a tide flows suddenly up a river encumbered with shoals, it

checks the descent of the stream; the water spreads over the sands, and a high crested wave, called a *bore*,[1] is driven with force up the channel. This occurs in the Hugli mouth of the Ganges, and in the Amazon at the equinoxes, where, during three successive days, five of these destructive waves, from 12 to 15 ft. high, follow one another up the river daily; and it occurs in a less degree in some of our British rivers.

Both the height and time of the tides vary with the moon's age.[2]

The friction of the wind combines with the tides in agitating the surface of the ocean, and according to the theory of undulations each produces its effect independently of the other; wind, however, not only raises waves, but causes a transfer of superficial water also. Attraction between the particles of air and water, as well as the pressure of the atmosphere, brings its lower stratum into adhesive contact with the surface of the sea. If the motion of the wind be parallel to the surface, there will still be friction, but the water will be smooth as a mirror; but if it be inclined, in however small a degree, a ripple will appear. The friction raises a minute wave whose elevation protects the water beyond it from the wind, which consequently impinges on the surface at a small distance beyond; thus each impulse, combining with the other, produces an undulation which continually advances.

Those beautiful silvery streaks on the surface of a tranquil sea, called cats' paws by sailors, are owing to a partial deviation of the wind from a horizontal direction. The resistance of the water increases with the strength and inclination of the wind. The agitation at first extends little below the surface, but in long continued gales even the deep water is troubled: the billows rise higher and higher, and as the surface of the sea is driven before the wind, their 'monstrous heads,' impelled beyond the perpendicular, fall in wreaths of foam. Sometimes several waves overtake one another and form a sublime and awful sea. The highest waves known are those which occur during a N.W. gale off the Cape of Good Hope, aptly called by the ancient Portuguese navigators the Cape of Storms: Cape Horn also seems to be the abode of the tempest. The sublimity of the scene, united to the threatened danger, naturally leads to an over estimate of the magnitude of the waves, which appear to rise mountains high, as they are proverbially said to do. There is every reason to believe that the waves of the Cape of Good Hope are occasionally 40 ft. from the hollow trough to the summit,

---

[1] A *bore* is the advancing edge or front of a tidal wave as it rushes up the channel of an estuary or river.

[2] Mr. Keith Johnston's 'Phys. Atlas,' in folio.

for Dr. Scoresby observed them to be of that height both in the Atlantic and during a cyclone he met with in his voyage to Australia in the 'Royal Charter.'[1] The waves are short and abrupt in small shallow seas, and on that account are more dangerous than the long rolling billows of the wide ocean.

The waves raised by the wind are altogether independent of the tidal waves; each maintains its undisturbed course; and as the inequalities of the coasts reflect them in all directions, they modify those they encounter and offer new resistance to the wind, so that there may be three or four systems or series of coexisting waves, all going in different directions, while the individual waves of each maintain their parallelism.

The undulation called a ground swell, occasioned by the continuance of a heavy gale, is totally different from the tossing of the billows, which is confined to the area vexed by the wind; whereas the ground swell is rapidly transmitted through the ocean to regions far beyond the direct influence of the gale that raised it, and it continues to heave the smooth and glassy surface of the deep long after wind and waves are at rest. In the South Pacific, billows which must have travelled 1000 m. against the trade wind from the seat of the storm, expend their fury on the lee side of the many coral islands which bedeck that sunny sea.[2] Thus a swell sometimes comes from a quarter in direct opposition to the wind, and occasionally from various points of the compass at the same time, producing a vast commotion even in a dead calm, without ruffling the surface. They are the heralds that point out to the mariner the distant region where the tempest has howled, and not unfrequently they are the harbingers of its approach. At the margin of the polar ice, in addition to other dangers, there is generally a swell which would be very formidable to the mariner in thick weather, did not the loud grinding noise of the ice warn him of its approach.

Heavy swells are propagated through the ocean till they gradually subside from the friction of the water, or till the undulation is checked by the resistance of land, when they roll in surf to the shore, or dash over the rocks in spray and foam. The rollers at the Cape de Verd Islands are seen at a great distance approaching like mountains. When a gale is added to a ground swell, the commotion is great and the force of the surge tremendous, tossing huge masses of rock and shaking the cliffs to their foundations. During

[1] Dr. Scoresby's Observations in the Atlantic, made with greater care than had been hitherto employed, confirms this result.—*Proceedings of British Association*, 1850.

[2] Beechey's 'Voyage to the Pacific.'

heavy gales on the coast of Madras the surf breaks in 9 fathoms water at the distance of 4 and even 4½ m. from the shore. The violence of the tempest is sometimes so intense as to quell the billows and scatter the water in a heavy shower called by sailors spoondrift. On such occasions saline particles have impregnated the air to the distance of 50 m. inland.

The force of the waves in gales of wind is tremendous. From experiments made by Mr. A. Stevenson, the celebrated engineer of the Skerryvore Lighthouse, on the W. coast of Scotland, exposed to the whole fury of the Atlantic, it appears that the average pressure of the waves during the summer months was equal to 611 pounds weight on a square foot of surface, while in winter it was 2086 pounds, or three times as great. During the storm that took place on March 9, 1845, it amounted to 6083 pounds. Now, as the pressure of a wave 20 ft. high not in motion is only about half a ton on a square foot, it shows how much of their force waves owe to their velocity. The rolling breakers on the cliffs on the W. coast of Ireland are magnificent: the Earl of Dunraven measured some, the spray of which rose as high as 150 ft.

In the Isle of Man a block, which weighed about 10 stone, was lifted from its place and carried inland during a N.W. gale; and in the Hebrides a block of 42 tons weight was moved several feet by the force of the waves. The Bell Rock Lighthouse in the North Sea, though 112 ft. high, is literally buried in foam and spray to the very top during ground swells when there is no wind. On November 20, 1827, the spray rose 117 ft., so that the pressure was computed by Mr. Stevenson to be nearly 3 tons on a square foot.

The effect of a gale descends to a comparatively small distance below the surface; the sea is probably tranquil at the depth of 200 or 300 yards; were it not so the water would be turbid and marine animals would be destroyed. Anything that diminishes the friction of the wind smoothes the surface of the sea—for example, oil or a small stream of packed ice, which suppresses even a swell. When the air is moist, its attraction for water is diminished, and consequently so is the friction; hence the sea is not so rough in rainy as in dry weather.

§ 4. **Currents.**—*Currents* of various extent, magnitude, and velocity disturb the tranquillity of the ocean; some of them depend upon circumstances permanent as the globe itself, others on ever-varying causes; the permanent and most important currents move in the great circles of the sphere. A perpetual circulation is kept up in the waters of the main by these vast marine streams; they are sometimes superficial and sometimes submarine, according as their density is greater or less than that of the surrounding sea. But

although they depend upon the same cause as the trade winds, they differ essentially in this respect, that whereas the atmosphere is heated from below by its contact with the earth, and transmits the heat to the strata above, the sea is heated at its surface by the direct rays of the sun, which produces a strong and rapid evaporation, especially in the tropical regions of the ocean, where the sea greatly exceeds the land in extent.

It is computed that 186,240 cubic m. of water are annually raised from the surface of the globe in the form of vapour, chiefly from the intertropical seas, part of which is restored to them in rain, but by far the greater part is carried by the winds to water the land and feed all the rivers and streams on the surface of the earth. The enormous quantity of water thus carried off by evaporation in the warm seas, which amounts to 139,680 cubic m. in the Indian and Pacific Oceans alone, disturbs the equilibrium of the seas, but it is restored by a perpetual flux of cold water from each pole towards the equator, and in some degree by vertical circulation.

When these streams of cold water leave the poles, they flow directly towards the equator; but before proceeding far their motion is deflected by the diurnal rotation of the earth. At the poles they have no rotatory motion, and, although they gain it more and more in their progress to the equator, which revolves at the rate of 1000 m. an hour, they arrive at the tropics before they have gained the same velocity of rotation with the intertropical ocean. On that account they are left behind, and consequently flow in a direction contrary to the diurnal rotation of the earth. Hence the whole surface of the ocean for 30 degrees on each side of the equator flows in a stream or current from E. to W. 3000 m. broad. The trade winds, which constantly blow in one direction, combine to give this great equatorial current a mean velocity of 10 or 11 m. in 24 hours.[1]

As soon as the water at the surface of the tropical seas becomes denser and salter than that immediately below from the evaporation, it sinks down, leaving a new surface to be acted upon; and were it not for the inhabitants of the deep, the buoyancy of those seas would be impaired. Insignificant as they may seem, the mollusca, corallines, and other marine animals which abound in such myriads in the sea, bear so important a part in these great operations of nature that Lieutenant Maury says, 'they have power to put the whole sea in motion from the equator to the poles and from top to bottom.' By abstracting the solid matter from the water to

[1] Winds are named from the points whence they blow, currents exactly the reverse. An easterly wind comes from the east; whereas an easterly current comes from the west, and flows towards the east.

build those immense coral reefs and islands, marl beds, shell beds, and infusorial deposits of enormous magnitude, it becomes buoyant, rises to the top, and supplies the place of that which has gone down, and which in its turn furnishes material for new deposits, and a new supply of water for the surface, an alternation as permanent as the currents themselves, and one of the most wonderful and beautiful adaptations of small means to a great end. The direct heat of the sun also increases the buoyancy of the water which flows in superficial currents towards the poles; but in going from the equator, where the rotation of the earth is at its maximum, to the poles, where there is none, they are deflected more and more towards the west, and gradually losing their warmth, they become heavy, sink down, and return again as under currents to join the equatorial stream. Thus polar currents flow to the equator, and equatorial currents flow to the poles, in a never-ending circuit coeval with the ocean itself, and which will be coexistent with it while time endures. This perpetual fluctuation of the waters of the ocean between the polar basins and the equator, as they become alternately warm and cold, is the cause of that admirable system of currents which combine with the winds to mitigate the cold of the frigid zone and temper the heat of the torrid.

The *Equatorial Current* of the Pacific and Indian Oceans may be regarded as one mighty stream flowing from E. to W. through about 255 degrees of longitude. It crosses the Pacific in a current nearly 3500 m. broad, between the parallels of 26° S. and 24° N. lat., thus spreading over nearly a third of the distance from pole to pole. Its breadth is much diminished in coming to the Indian Archipelago, as in the Indian Ocean it flows between the 10th and 20th degrees of S. latitude.

In the North Pacific there are many offsets from the main flow, but by far the most remarkable originates in the Indian Ocean. It is known as the *Chinese Current*, or the *North Pacific Gulf Stream*. It flows through the Strait of Malacca, and after being joined by warm streams from the Java and China Seas it passes into the Pacific between the Philippines and the coast of Asia; from thence it flows to temper the climate of the Aleutian Islands, and is lost in its progress towards the coast of North America. Between this and the coast of Japan a cold current comes from the Sea of Okhotsk, which is as much celebrated for its fisheries as the cold stream which flows over the great banks of Newfoundland in the Atlantic. It causes dense fogs on the coasts of Yeso, the Kurile Islands, and Kamtschatka, for the same reason that the Gulf Stream occasions those on the banks of Newfoundland.

The two great oceans under consideration being all but land-

locked to the N., the principal exchange of warm and cold water is between the southern side of the equatorial current and the Antarctic Ocean. The warm streams which that current sends off in the Indian Ocean, from water occasionally at the temperature of 90° Fahr., must be of great magnitude. One of these leaves the main stream between Africa and Australia, and flowing S., ends in a motionless sea of weeds similar to the Grassy Sea in the Atlantic.

The equatorial current in the Indian Ocean is divided as it approaches Madagascar; one part runs to the N.W., bends round the northern end of Madagascar, flows through the Mozambique channel and, being joined by the other branch, doubles the Cape of Good Hope outside the Agulhas Bank, and meeting with a warm current from the Atlantic becomes lost farther S. Cold currents from the Antarctic Ocean come on each side of the weedy sea, and sometimes bring icebergs as low as the 40th parallel. A branch of these cold currents, striking the Cape from the S.W., runs northward along the W. coast of Africa and is the cause of the cool seas and fogs at Walfisch Bay and other places on this coast.

In the South Pacific, Maury discovered a very large branch which leaves the equatorial flow midway between the coast of America and Australia, and after a winding course trends to the Antarctic Sea. This current enabled Sir James Ross to penetrate farther to the S. than Captain Wilkes; it is the highway to the Antarctic Seas. On each side of it branch off cold currents from the S., one along the coast of Australia, and the other known as Humboldt's current, in some places nearly 1000 fathoms deep, along the South American coast, tempering the heat of the rainless shores of Peru, and is felt even at the equator for a distance of 3500 m. from the American coast. Between this current and the great equatorial stream lies the 'Desolate Region,' an area of the ocean that ships seldom crossed till the discovery of the gold mines in Australia and the Guano islands of Peru. Whales rarely come near it; even the sea birds which so frequently accompany ships in these southern seas abandon them on approaching it, and the sea itself is comparatively barren of animal life.

Drift Currents depend upon the winds. The Pacific is under the influence of the trade winds which produce constant currents; and the *Monsoons*, which cause drift currents, setting alternately in one direction and then in the other, prevail chiefly in the Indian Ocean. These periodic winds, depending on the seasons, regulate the navigation in the Bay of Bengal and in the Arabian sea. Temporary currents raised by partial evaporations, changes in atmospheric pressure, and very heavy rains are frequent in the tropical regions.

From the South Polar Ocean an ice bearing current passing E. of Cape Horn brings icebergs even to 36° S. lat., as far as which they have been seen off the S. coast of Africa.

The *Equatorial Atlantic Current* pursues its western course, 160 m. broad, to mid-ocean where it sends off the N.W. branch, and on arriving at San Roque on the American coast, is divided into the Brazil and Guiana currents, the first of which sets along the South American shores so strongly that it is not deflected by the mass of water flowing into it from the Rio de la Plata; yet it is lost before arriving at Cape Horn. The Guiana branch, by much the largest, undisturbed by the powerful rivers Amazon and Orinoco, flows to the West Indian Islands; there it joins the main equatorial flow, and the united streams enter the Caribbean Sea after a course of 4000 m. across the Atlantic with a velocity varying with the seasons, but on an average about 30 m. in 24 hours. From the Caribbean Sea it sweeps round the Gulf of Mexico and rushes through the Strait of Florida, the mightiest and most beautiful oceanic river in existence; its source under the Tropic of Cancer, its mouth in the Arctic Ocean. Its current is more rapid than those of the Mississippi or the Amazon, and its volume a thousand times as great. In the Strait of Florida it is 32 m. wide, 2220 ft. deep, and flows at the rate of 4 m. an hour. Its waters are of the purest ultramarine blue as far as the coasts of Carolina, and so completely is it separated from the sea through which it flows, so sharp the line of separation, that a ship may be seen at times half in the one and half in the other. It is 86° Fahr. at the surface, at the Strait of Bemini, and after running 3000 m. to the N. it still preserves a summer heat, yet its banks and bottom are cold. As it proceeds in its northern course towards Newfoundland it is deflected eastward, forming, as nearly as possible, a great circle of the sphere, the shortest distance between two points on its surface, which is the course of currents in general, whether of air or water, unless diverted by local circumstances.

The *Gulf Stream*, in its course towards the British Islands, the North Sea, and the Frozen Ocean, follows the same law. At Cape Hatteras it begins to increase in width, it is deflected nearly to the E. by the banks of Newfoundland; and between 38° and 40° W. long. it spreads out like a fan from the Canaries to the Arctic Ocean, one branch sweeping round the W. coast of Iceland and the other N.E. to the coasts of Norway and Spitzbergen. The presence of these currents is recognised by their greater warmth, even among the polar ice, and in consequence of some of them the Spitzbergen Sea is 6 or 7 degrees warmer at the depth of 200 fathoms than at the surface. Thus the warmth of that great oceanic river tempers the severity of the climates even to Spitzbergen, and

but for its mild influence, the shores of the British Isles would be very much colder than they now are. Maury says, though the warmth of the Gulf Stream diminishes as it runs N., the quantity of heat which it spreads over the Atlantic in a winter's day would be sufficient to raise the whole atmosphere that covers France and Great Britain from the freezing point to summer heat, and is the principal cause of the mildness and damp of Ireland and of the S. of England.

Towards the Azores a portion of the Gulf Stream bends round, and after uniting with Rennell's Current, from the British Channel, runs along the African coast, and rejoins the great equatorial flow, having made a circuit of 3800 m. with varying velocity, leaving a space of 260,000 sq. m. of nearly motionless water between the Azores, the Canaries, and Cape de Verd Islands. This great area is the Grassy or Sargasso Sea, so called from its being so thickly covered with the seaweed, called *Fucus* or *Sargassum natans*,[1] that at a certain distance it seems solid enough to walk upon. These seaweeds probably grow on the spot, but the great accumulation is partly due to the circumstance that everything that floats on the Gulf Stream, as well as the stream itself, trends to the E., so the weeds and substances that come from other parts of the Atlantic to the Gulf Stream are carried across it to its eastern side. The bodies of animals and plants of unknown appearance to Columbus and his companions, brought to the Azores by this cause, suggested to that great man the idea of land beyond the Western Ocean, and thus led to the discovery of the New World.

It is a common practice with navigators to throw bottles overboard containing the date and position of the ship. A chart has been formed showing the direct course which a number of these bottles have taken in the Atlantic, whence it appears that those thrown in S. of 45° N. lat. arrive either at the Gulf of Mexico or the West Indies; while those committed to the deep N. of that parallel reach the coasts of Europe by the Gulf Stream or its branches; Maury mentions, however, an instance of a bottle thrown overboard from an American ship off Cape Horn, in 1837, being afterwards found on the coast of Ireland. It appears that the Gulf Stream takes 8 months to flow from the Gulf of Mexico to the shores of Europe, and that the broader and slower current takes 12 months to travel from the Bay of Biscay back to the Gulf of Mexico, periods which closely accord with the time occupied by the drift of bottles.

[1] The *Macrocystis pyrifera* is also found in the Grassy Sea; the stem is not thicker than a man's finger, but from 1000 to 1500 ft. long, branching upwards in filaments like packthread.

In the Atlantic the trade winds only blow steadily between the parallels of 23° N. and 9° S. lat., and between these limits drift currents run with a velocity of from 9 to 10 m. in 24 hours. In the calm regions these currents are very feeble, and in the extra-tropical seas, like the prevailing winds, the drift currents are not so steady, they do not always flow in the same direction, nor with the same velocity.

In summer the *Great North Polar Current* descending along the E. coast of Greenland, together with the current from Davis Strait, bring icebergs to the margin of the Gulf Stream. The difference between the temperatures of these two oceanic streams at their contact is the cause of the dense fogs that hang over the banks of Newfoundland. The North Polar Current runs inside the Gulf Stream, along the coast of North America to Florida, and beyond it, since it sends an under current into the Caribbean Sea. As early as the year 1838 Mr. W. C. Redfield expressed an opinion that the Arctic Current, after passing the banks of Newfoundland, flows beneath the Gulf Stream to the S. and S.W., a theory that has been confirmed by the American navigators who have found that at the depth of 370 fathoms the bed of the Gulf Stream, in its warmest and narrowest part, has a temperature of 32° Fahr., so that it flows on a cushion of cold water. In longitude 46° W., Commander Dayman found that the water had a temperature of 39°·7 at a depth of 1000 fathoms in two instances, showing a remarkable contrast at so small a distance; but water of the temperature of 30° has been found at great depths by Dr. Carpenter and other recent observers much farther E. The current of cold water that extends from Cape Hatteras to the S.E. of the Bermuda Islands, as well as the cold bands found in the Gulf Stream, are no doubt detached portions of the Arctic Current. The fish which abound to excess in this cold current never enter the Gulf Stream, the existence of which was made known by the whales avoiding its warm waters. Counter currents on the surface are of such frequent occurrence that there is scarcely a strait joining two seas that does not furnish one—a current running in along one shore, and a counter current running out along the other. One of the most remarkable occurs in the Atlantic: it begins off the coast of France and, after sending a mass of water into the Mediterranean, follows a southerly direction at some distance from the continent of Africa until after passing Cape Mesurada, when it flows rapidly for 1000 m. due E. to the Bight of Biafra, in immediate contact with the equatorial current, running with great velocity in the opposite direction and appears finally to merge in the latter.

Periodical Currents are frequent in the eastern seas: one flows into the Red Sea from October to May, and out of it from May to

October. In the Persian Gulf this order is reversed; in the Indian Ocean and China Sea the waters are driven alternately in opposite directions by the Monsoons. It is the S.W. Monsoon that causes inundations in the Ganges, and a tremendous surf on the coast of Coromandel. The tides also produce periodical currents on the coasts and in straits, the water running in one direction during the flood, and the contrary way in the ebb. The Roost of Sumburgh, at the southern promontory of Shetland, runs at the rate of 15 m. an hour; indeed the strongest tidal currents known are among the Orkney and Shetland Islands; their great velocity arises from local circumstances. Currents in the wide ocean move at the rate of from 1 to 3 m. an hour in their centre; but the velocity is less at the sides and bottom of the stream, on account of friction.[1]

Whirlpools are produced by opposing winds and tides; the whirlpool of Maelström, on the coast of Norway, is occasioned by the meeting of tidal currents between Moskenö and Vœrö, the two southernmost islands of the Lofoden group; it is $1\frac{1}{2}$ m. in diameter and so violent that its roar is heard at the distance of several leagues. But the danger to be apprehended from it has been much exaggerated.

What with *Winds, Tides,* and *Currents,* the ocean is never at rest. Even in the equatorial regions far from land, where dead calms prevail, and the sea is apparently in the most perfect stillness, day after day partaking of the universal quiet, it heaves its low flat waves in noiseless and regular periods: the ocean is only asleep; its pulse continues to beat, and evaporation keeps the particles of its glassy surface in ceaseless motion. The calm of the equatorial sea is sometimes disturbed by a superficial tumult in the water called tide rips, which move along with a threatening aspect and roaring noise.

The safety and length of a voyage depend upon the skill with which the navigator avails himself of the set of the different currents, and the direction of the permanent and periodical winds; the course is frequently shortened by following a very circuitous track to take advantage of them if favourable, or to avoid them if unfavourable. From Acapulco, in Mexico, across the Pacific to Manilla or Canton, the trade wind and the equatorial current ar so favourable that the voyage is accomplished in 50 or 60 days; whereas in returning, 90 or 100 are required. Within the Antilles navigation is so difficult from winds and currents that a vessel going from Jamaica to the Lesser Antilles cannot sail directly

[1] The reader is referred to the works of Maury, Cooley, Reclus, and Dr. Johnston, for a more extensive account of currents in the ocean.

across the Caribbean Sea, but must go round about through the windward passage between Cuba and Haiti to the ocean; nearly as many weeks are requisite to accomplish this voyage as it takes days to return. On account of the prevalence of W. winds in the North Atlantic the voyage from Europe to the United States is longer than that from the latter to Europe; the Gulf Stream is avoided in the outward voyage, and advantage taken of it in returning. Ships going to the West Indies, and to Central or South America, from Europe, generally make the Canary Islands in order to fall in with the N.E. trade winds which carry them to within 10 degrees of the equator.

The passage to the Cape of Good Hope from Great Britain may be undertaken at any season, and is accomplished in 50 or 60 days; but it is necessary to regulate the voyage from the Cape to India and China according to the season of the Monsoons. There are various courses adopted for that purpose, but all of them pass through the very focus of the hurricane district, which includes the islands of Rodriguez, Mauritius, and Bourbon, and extends from Madagascar to the Island of Timor.

The shortest distance between any two points on the surface of the globe is the arc of a great circle; hence the length of a voyage will depend upon the skill in keeping that line as nearly as the winds and currents will permit, but the currents either do or tend to follow that line. The physical geography of the sea is now sufficiently well known to enable the mariner, by the aid of charts of the winds and currents, to pursue his course across the trackless ocean with as much confidence and certainty as if it were a railway. Maury gives an instance of two large ships which left New York for California, a distance of 15,000 m. One, which was the faster sailer, set out nine days later, overtook and spoke to the other off Cape Horn, passed on, and arrived first. They were unconnected, but running against time; and after the voyage, when their courses were laid down on the chart, they were all but identical. Another instance is given of a race between three vessels going the same long voyage, quite unconnected, who yet, amidst all the vicissitudes of climate, winds, and currents, passed, repassed, and frequently recognised each other, as if they had been on a racecourse.

§ 5. **Temperature of the Ocean.**—Since water is a bad conductor of heat, the temperature of the ocean is less liable to sudden changes than the atmosphere; the influence of the seasons is imperceptible at the depth of 200 ft.; and the direct heat of the sun does not affect the bottom of a deep sea. From recent observations of deep sea temperatures by the 'Challenger' expedition it would seem that over the whole bottom of the Pacific and the Atlantic, and those parts of the Southern Sea which were ex-

amined, the temperature is generally a little above the freezing point. In places in the valleys it was found to sink a little below the freezing point; but such extremely cold water was met with in one or two places only in the Atlantic and Pacific Oceans. Over the elevations the temperature was somewhat higher; but in the Atlantic and Pacific, as a rule, the rise of temperature on the ordinary elevations of the bottom of the sea is not above two or three degrees. On examination, the temperature of such an ocean as the Atlantic was found gradually to sink from the surface to the bottom. On the surface the height of the temperature is known to be according to the season of the year, the latitude, and the heat of the sun at the locality observed. Often the temperature falls rapidly for a certain distance and then gradually till at a depth of 500 fathoms it stands at about 45° Fahr. From that point, as has been already elsewhere said, the fall of temperature is gradual until the region of the freezing point is reached.[1]

The temperature of the *surface* of the ocean decreases from the equator to the poles. For 10 degrees on each side of that line E. of New Guinea the maximum is 84°·5; from thence to each tropic the decrease varies considerably. The tropical temperature would be greater were it not for the currents. In the torrid zone the surface of the sea is about 3° Fahr. warmer than the air above it, because the polar winds, and the great evaporation which abstracts the heat, prevent equilibrium; and as a great mass of water is slow in following the changes in the atmosphere, the vicissitude of day and night has little influence, whereas in the temperate zones it is perceptible.

The line of *maximum temperature*, or that which passes through all the points of greatest heat in the ocean, is very irregular, and does not coincide with the terrestrial equator; six tenths of its extent lie on an average 5° to the N. of it, and the remainder runs at a mean distance of 3° on its southern side. It cuts the terrestrial equator in the middle of the Pacific Ocean in 120° W. long. in passing from the northern to the southern hemisphere, and again through the Solomon Islands in returning from the southern to the northern. Its maximum temperature in the Pacific is 84°·5 Fahr. on the eastern shores of New Guinea, where it touches the terrestrial equator, and its highest temperature in the Atlantic, which is 83°·5, lies in the Caribbean Sea, off Belize, which furnishes the warm water of the Gulf Stream.

---

[1] See Sir C. Wyville Thomson's paper read at the Glasgow Meeting of the British Association on September 11, 1876.

The superficial water of the *Pacific* is much cooled on the E. by the Antarctic or Humboldt's Current. It is about 10° colder than the adjacent ocean, and renders the air much cooler than the surrounding atmosphere.

In the *Indian Ocean* the highest temperature of the surface water (81°·9) is in the Arabian Sea, between the coast of Africa and Ceylon.

The *superficial temperature* diminishes from the tropics with the increase of the latitude more rapidly in the southern than in the northern hemisphere.

§ 6. **Icebergs: Polar Ice; Submarine Currents.**—Icebergs come to a lower latitude by 10° from the S. pole than from the N.; they have been seen near the Cape of Good Hope, and are often of great size; one observed by Admiral Dumont d'Urville was 13 m. long, with perpendicular sides 100 ft. high above the water: they are less varied in shape than those in the northern seas. The discovery ships under the command of Sir James Ross met multitudes with flat surfaces, bounded by perpendicular cliffs on every side, from 100 to 180 ft. high, sometimes several miles in circumference. Their size must have been enormous, since more than two thirds of their mass was below water. From the condensation of moisture in the surrounding air by their cold, they are often enveloped in mist, which makes them still more formidable to navigators. Packed ice too is often in immense quantities: these ships forced their way through a pack 1000 m. broad, often under the most appalling circumstances. It generally consists of smaller pieces than the packs in the comparatively tranquil N. polar seas, where they are often several miles in diameter, and where fields of ice extend beyond the reach of vision. The Antarctic Ocean, on the contrary, is almost always agitated; there is a perpetual swell, and terrific storms are common, which break up the ice and render navigation perilous. The floebergs are rarely a quarter of a mile in circumference, and generally much smaller.

A more dreadful situation can hardly be imagined than that of ships beset during a tempest in a dense pack of ice in a dark night, thick fog, and drifting snow, with the spray beating perpetually over the decks and freezing instantaneously. Sir James Ross's own words can alone give an idea of the terrors of one of the many gales which the two ships under his command encountered: 'Soon after midnight our ships were involved in an ocean of rolling fragments of ice, hard as floating rocks of granite, which were dashed against them by the waves with so much violence that their masts quivered as if they would fall at every successive blow; and the destruction of the ships seemed inevitable from the tremendous shocks they

received. In the early part of the storm the rudder of the "Erebus" was so much damaged as to be no longer of any use; and about the same time I was informed by signal that the "Terror's" was completely destroyed and nearly torn away from the stern post. Hour passed away after hour without the least mitigation of the awful circumstances in which we were placed. The loud crashing noise of the straining and working of the timbers and decks, as they were driven against some of the heavier pieces of ice, which all the exertions of our people could not prevent, was sufficient to fill the stoutest heart, that was not supported by trust in Him who controls all events, with dismay; and I should commit an act of injustice to my companions if I did not express my admiration of their conduct on this trying occasion. Throughout a period of 28 hours, during any one of which there appeared to be very little hope that we should live to see another, the coolness, steady obedience, and untiring exertions of each individual were every way worthy of British seamen.

'The storm gained its height at 2 P.M., when the barometer stood at 28·40 inches, and after that time began to rise. Although we had been forced many miles deeper into the pack, we could not perceive that the swell had at all subsided, our ships still rolling and groaning amidst the heavy fragments of crushing bergs, over which the ocean rolled its mountainous waves, throwing huge masses upon one another, and then again burying them deep beneath its foaming waters, dashing and grinding them together with fearful violence.'

For three successive years were these dangers encountered during this bold and hazardous enterprise. It was impossible to pass the winter in these southern seas, but in the various expeditions to the Arctic Ocean the ships were frozen fast in boundless fields of ice for many months, ready to continue their perilous voyage as soon as the late and short summer should break it up.

The area of the Arctic Ocean is said to be about 5,692,000 sq. m., and is always at the freezing point of fresh water. In winter it is encircled by a zone of ice extending northwards towards the pole. The outline of this zone, though subject to partial variations, is found to be nearly similar at the same season of each succeeding year, yet there are periodical changes in the ice which are renewed after a series of years. The ice from the N. extends so far S. in winter as to render the coast of Newfoundland inaccessible; it envelops Greenland, sometimes even Iceland, and always invests Spitzbergen and Novaia Zemlia.

As the sun comes N. the zone of ice breaks up into enormous masses of what is called packed ice. Floating fields of ice, 20 or 30 m. in diameter, are frequent in the Arctic Ocean; their

thickness, which varies from 10 to 80 ft., is not seen, as there is at least two thirds of the mass below water. Sometimes these fields, many thousand millions of tons in weight, acquire a rotatory motion of great velocity, dashing against one another with a tremendous collision. Packed ice always has a tendency to drift southwards even in the calmest weather; and in their progress the ice fields are rent in pieces by the swell of the sea.

Huge icebergs and floebergs detached from enormous masses of ice that fill the Greenland fjords and the adjoining seas, are drifted southward 2000 m. to melt in the Atlantic, where they cool the water for 30 or 40 m. around, and the air to a much greater distance. They vary from a few yards to miles in circumference, and rise several hundred feet above the surface. When there is a swell, the loose ice dashing against them raises the spray to their very summits, and as they waste away they sometimes lose their equilibrium and roll over, causing a swell which breaks up the neighbouring field ice; the commotion spreads far and wide, and the uproar resounds like thunder.

Icebergs have the appearance of chalk cliffs with a glittering surface and emerald green fractures. Pools of azure blue water lie on their surface, or fall in cascades from them. The field ice also, and the masses that are heaped upon its surface, are extremely beautiful from the vividness and contrast of their colouring. A peculiar blackness in the atmosphere round a bright haze at the horizon indicates their position in a fog, and their place and character are shown at night by the reflection of the *snow light* on the horizon. An experienced seaman can readily distinguish by the *blink*, as it is termed, whether the ice is newly formed, heavy, compact, or open. The blink, or snow light, of field ice is the most lucid and is tinged with yellow; of packed ice it is pure white; ice newly formed has a greyish blink; and a deep yellow tint indicates snow on land.

The Pacific is only connected with the Arctic Ocean by Behring Strait, through which narrow channel a surface current sets to the N.; but the Atlantic penetrates far beyond the Arctic Circle to the E. of Greenland, and also into Davis Strait, which last spreads out into Baffin Bay, which is very deep, and subject to all the rigours of an Arctic winter, the very storehouse of icebergs, the abode of the walrus and the whale; Baffin Bay itself is but the highway by Smith Sound, Kennedy Channel, and Robeson Channel to the Polar Ocean, which in its northern prolongation occupies an area of 1,500,000 sq. m., as yet unexplored.

There is a perpetual circulation of water between the Arctic Ocean and the Atlantic. Currents of cold water flow southwards on the surface of the Arctic Ocean into the Atlantic, while sub-

marine currents of warmer water come from the Atlantic to the Arctic Seas: the freshness of the former, from the melting of the ice as the sun travels N., making it buoyant, though cold; and the saltness of the other making it heavy, though comparatively warm. But in time the qualities of each are changed, and they return to the oceans whence they came to maintain the equilibrium of the seas.

The surface current must be extremely powerful, for a field of ice, 300,000 sq. m. in extent, carried the 'Resolute' firmly fixed in it for 1000 m. to the S. The 'Resolute' had been abandoned by Captain Kellett some years before being sealed up in that mass of ice, at Melville Island, and was found in the midst of Baffin Bay by some American whalers, by whom she was taken to the United States, purchased by the Government of that country, and courteously restored to Her Majesty. Lieutenant De Haven, who was generously sent in the brig 'Advance' by the United States in search of Sir John Franklin, was frozen up for 9 months in a field of ice of equal magnitude mid channel in Davis Strait, and was carried by the current to the S. for 1000 m. The average thickness of the ice was 7 ft., and Maury computed that an area of ice of 300,000 sq. m. 7 ft. thick would weigh 18 billions of tons, and that a quantity of water many times greater would be required to float or drive this mass through Davis Strait.

§ 7. **The North West Passage; Attempts to accomplish it.**—The Russians would be saved a voyage of 21,658 m. could they cross the pole and pass through Behring Strait to their N. Pacific settlements instead of going by Cape Horn; and a direct course from the Thames, across the North Pole, to Behring Strait, would only be 4113 m. But even if the pole could not be attained, it would evidently be of the greatest advantage to all the maritime nations of Europe were it possible to sail from the Atlantic to the Pacific Ocean by the northern coasts of America. The hopes of being able to accomplish this N.W. passage has led to numerous voyages, in which the highest qualities and virtues of man have been displayed.

War had for many years put a stop to enterprise when Dr. Scoresby, on a whaling voyage with his father in 1806, reached the parallel of 81° 30′ N., midway between Greenland and Spitzbergen, where the sea was open for 18,000 sq. m., and he afterwards found the E. coast of Greenland, hitherto supposed to be inaccessible free from ice from 70° to 80° N. lat., and for 10° of longitude. In consequence of these discoveries the hope of penetrating to the Arctic Ocean revived, and in 1818 four ships were sent by the British Government to find their way N. about to Behring Strait; two, commanded by Captains Parry and Ross, were to proceed by

Davis Strait, and the other two, under the command of Captains Buchan and Franklin, by the open sea at Spitzbergen across the pole. Both failed in the object of their mission, and from that time to 1845 numerous similar attempts were made without success. After spending years in these dreary regions, they all returned baffled by impenetrable barriers of ice, not, however, without having made important discoveries both in geography and general science.

In 1845 a new expedition was planned, and a great number of volunteers, both of men and officers, offered to embark for the ice bound seas of the N., notwithstanding the sufferings and dangers which they knew awaited them, and which many of them had already experienced. The command offered by the Admiralty was joyfully accepted by Sir John Franklin, on his return from having governed Tasmania for several years. He was an honour even to the British navy, where there is so much honour. Besides long voyages in various parts of the world, he had in former years made two in the Arctic Seas, so he was perfectly acquainted with all that was requisite for that difficult navigation. The expedition consisted of two screw steamers, perfectly equipped and prepared to resist the pressure of the ice, furnished with everything that was necessary, and a transport accompanied them to Davis Strait to complete their supply of provisions. Sir John commanded the 'Erebus,' and Captain Crozier, who had been second in command in the Antarctic Seas with Sir James Ross, and had made two Arctic voyages with Sir Edward Parry, commanded the 'Terror.' Their orders were to proceed by Lancaster Sound and Barrow Strait to 74° 30′ N. lat., from thence to make Cape Walker in 98° W. long., and then to find their way to Behring Strait. They sailed from the Thames on May 19, and arrived in safety at Whalefish Island on the E. coast of Davis Strait. There they wrote the last letters that ever were received from them, and the ships were seen for the last time on July 26 by the 'Prince of Wales' whaler, moored to a floating mass of ice in 76° 48′ N. lat. and 66° 13′ W. long.

Although it was known that the voyage would last more than one year, fears were felt for their safety as early as 1848, and from that time one expedition after another was sent, some by Davis and others by Behring Strait; yet with all the advantages of scientific knowledge, steam, and practical skill, the intricacies of these frozen seas were searched in vain, though searched with the zeal of affection and friendship. Lady Franklin, for whom everyone felt the deepest sympathy, sent two ships and aided in the equipment of a third; her long continued hope and energy lasted long after all hope was at an end. Even after the lapse of more than 11 years her affection induced her to send a steamer to the

Arctic Seas, trusting that the crews might still exist among the horde of Esquimaux, or that some relics of them might be found should they have perished.

Two of the expeditions were attended by great and important results. The 'Enterprise' and 'Investigator,' commanded by Captains Collinson and M'Clure, sailed on January 10, 1850, for Behring Strait. Captain M'Clure in the 'Investigator' arrived first, passed through the strait, and with great difficulty touching at Capes Barrow and Parry, steered N. through an open sea to an unknown land, which turned out to be Banks Land, or island, so named by Sir Edward Parry, who had seen its northern coast during the memorable winter he spent at Melville Island. Captain M'Clure then sailed through a strait between that island and Prince Albert Land to 73° N. lat., since called Prince of Wales Strait. Being prevented by ice from proceeding farther, Captain M'Clure turned back, and was frozen up in the strait for 9 months. During that time excursions were made in various directions in search of the missing ships, but in vain. In one of these excursions it was found that Prince of Wales Strait opened into Barrow Gulf, which leads by the Straits of Barrow and Lancaster into Baffin Bay; and as these latter had been previously examined from the eastward by Parry and others, this discovery settled the question of the N.W. passage, which Captain M'Clure has had the honour of having effected—the object of so many voyages of peril and suffering.

In the late spring of 1852 the 'Investigator' was released from its icy prison, but, finding it impossible to enter Barrow Gulf, and wishing to reach Melville Island before another winter, Captain M'Clure sailed round the W. side of Banks Land, but could get no farther than a deep bay on the N. side, where he wintered, and to which he gave the name of the Bay of God's Mercy. After being so long at sea, their provisions began to fail, but at first the deer and musk oxen, which abound in the island, furnished them with plenty of food; however, the winters of 1852–3 were uncommonly severe, the men had to go far in chase of these animals, by degrees their strength failed, they became low, sickly, and dispirited. It was an arduous journey of 10 days over the ice to Melville Island, nevertheless Captain M'Clure effected it without any loss, and deposited a paper at the spot where Sir Edward Parry had passed a winter, in which he gave information of his situation, begged for aid, and requested that those who might find it would forward it to England. At the same time impressed, after his long imprisonment in the ice, with the necessity of taking some decisive step for their rescue, it was determined that one part of the crew, under command of the first lieutenant, should find their way to M'Kenzie

River, and that with the rest the captain should patiently await the breaking up of the ice, and endeavour to navigate the ship to Baffin Bay.

Anxiety now began to be felt for the fate of this expedition also, and another, consisting of four ships, sailed from England, under the command of Sir Edward Belcher, in April 1852, for Davis Strait. Two of the vessels were to go in search of Sir John Franklin; the others, including the 'Resolute,' commanded by Captain Kellett, had orders to deposit provisions in Melville Island for the 'Enterprise' and 'Investigator,' should they call there. On arriving they found the documents deposited by Captain M'Clure, and a party soon after set out to discover if he was still in the Bay of God's Mercy.

On the day before their intended separation (April 19, 1853), Captain M'Clure and his first lieutenant were walking on the ice, when they saw a man running, and thought it one of the crew chased by a bear—it was Lieutenant Pim of the 'Resolute.' Words fail to describe that meeting—they were at last rescued from their perils. The joy of the ship's company and their gratitude to God for their deliverance were unbounded. Means were immediately adopted for conveying over the ice to Melville Island the 'Investigator's' exhausted crew, where they arrived in June: a portion remained there, the most robust having proceeded to the general rendezvous at Beechey Island. All, however, were destined to spend another dreary winter in the ice; but on Sir Edward Belcher ordering the abandonment of all the ships under his orders engaged in the search for Franklin in May, their united crews, including that of the 'Investigator,' embarked for England, which they reached in the autumn of 1854.

Not discouraged by so many failures, Lady Franklin fitted out a fourth expedition, under the command of Captain (now Sir Leopold) M'Clintock, who sailed from Aberdeen in the 'Fox' on July 17, 1857. His ship was beset by ice between Melville Bay and Lancaster Sound, and drifted back with the ice through 1375 m. On the breaking up of the ice Captain M'Clintock continued his voyage and research under circumstances of great peril, but it was not till the spring of 1860 that any traces of the lost expedition were obtained. On the N.W. shore of King William's Island, so desolate that even the wandering Esquimaux never approach it, a tin case that had been buried in a cairn 12 years before was discovered. It contained a written document, in which it was recorded that Sir John Franklin died on June 11, 1847, that the ships had been abandoned about 15 m. to the N.N.W. of that desert island, and that 105 of the survivors intended to proceed next day to Back's Fish River. These must have perished

on the way. Of the 2000 m. of ocean forming the N.W. passage between the Atlantic and Pacific, no less than 1260 m. had been investigated under the command of Sir John Franklin either by ship or boat, and in this last and fatal voyage 560 m. of unknown sea had been navigated; so that he and his companions have the honour of being the first to make the N.W. passage, but the way was prepared by the numerous brave men who had navigated these ice clad seas for forty years. Captain M'Clintock and his officers discovered 600 m. of new coast line of North America, and to this extent increased our geographical knowledge of the Arctic limits of that continent.

In 1871, 1872, and 1873 Mr. B. Leigh Smith made three most interesting expeditions for the purpose of attaining the highest possible latitude and of exploring the unknown lands to the E. of Spitzbergen.

An American expedition was sent out in 1871 under Captain Hall, who carried his ship—the 'Polaris'—to the highest lat. (82° 16′ N.) which any ship had up to that time reached. His death put an end to the expedition.

The Austrians sent out an expedition in 1872–4 under Lieut. Payer, who discovered Franz-Joseph Land, an archipelago N. of Novaia Zemlia between the parallels 80° and 83° N. lat. Sledging parties reached 82° 5′ N. lat., whence land was sighted at a considerable distance.

On May 29, 1875, two vessels, the 'Alert' and the 'Discovery,' manned by picked sailors and equipped with all the means and appliances which experience could suggest, were placed under the command of Captains Nares and Stephenson, and sent forth from Portsmouth by the British Government for a more complete exploration of the N. Polar regions. Having penetrated to a spot within 400 m. of the N. Pole, they found instead of an open Polar sea a sea of ice of unusual age and thickness, which they named the 'Palæocrystic Sea,' or 'Sea of Ancient Ice.' The 'Discovery' was laid up for the winter at the S.E. corner of Lady Franklin Bay in lat 81° 44′ N. The 'Alert' pushed forward until she encountered a wall of impenetrable ice on every side; no harbour being obtainable the ship was secured inside a sheltering barrier of grounded ice in lat. 82° 27′ N. And in these quarters the ships' crews respectively wintered. In the spring sledge parties were despatched E. and W. and N. The Northern party under Commander Markham and Lieutenant Parr were absent 72 days and succeeded in planting the British Flag in lat. 83° 20′ 26″ N., the most northerly point yet reached by man. The party that went W. commanded by Lieutenant Aldrich, traced the coast line for a distance of 220 m. from the position of the 'Alert,' to a spot

in 82° 10′ N. lat., and 86° 30′ W. long. The northernmost headland was found in 83° 7′ N. lat. and was named Cape Columbia. Lieutenants Beaumont and Rawson of the 'Discovery' had charge of the E. party; and they explored the coast of Greenland, reaching a position 70 m. N.E. of Repulse Harbour in lat. 82° 18′ N., long. 50° 40′ W. Lady Franklin Sound and Petermann Fjord were also explored; and President Land, which recent maps have been showing in about 84° N., has been proved to have no existence. There being no object to be gained by spending another winter in these regions the good ships left their quarters in the summer and reached Portsmouth on November 1, 1876. Although a temperature of 104° below freezing point was encountered only one death resulted from frost bite. Three men, however, died from scurvy, but these were the only losses sustained by the expedition.

§ 8. **Inland Seas.**—The ocean is one mass of water, which, entering into the interior of the continents, has formed seas and gulfs of great magnitude, that afford easy and rapid means of communication, while they temper the climates of the widely expanding continents.

The inland seas communicating with the Atlantic are larger and penetrate more deeply into the continents than those connected with the great ocean; a circumstance which gives a coast line of 48,000 m. in extent to the former, while that of the great ocean is only 44,000. Most of these internal seas have extensive river tributaries, so that by inland navigation the Atlantic virtually enters into the deepest recesses of the land, brings remote regions into contact, and improves the condition of the less cultivated races of mankind by commercial intercourse with those that are more civilised.

The *Baltic*, which with its arms has an area of 134,900 sq. m. in the centre of Northern Europe, is one of the most important of the inland seas connected with the Atlantic, and although inferior to the others in size, the drainage of more than a fifth of Europe flows into it. Only about a fourth part of the boundary of its enormous basin of 900,000 sq. m. is mountainous; and so many navigable rivers flow into it from the watershed of the great European plain, that its waters are nearly a fourth less salt than those of the Atlantic: it receives at least 250 streams. Its depth nowhere exceeds 120 fathoms, and generally it is not more than 40 or 50. From that cause, together with its freshness and its higher northern latitude, the Baltic is frozen during 5 months in the year.

From the flatness of the greater part of the adjacent country, the

[1] See Captain Nares' Report to the Lords Commissioners of the Admiralty.

climate of the Baltic is subject to influences that have their origin in regions far beyond the limits of its river basin. The winds from the Atlantic bring warmth and moisture which, condensed by the cold blasts from the Arctic plains, falls in rain in summer, and deep snow in winter, which diminishes its saltness; but an under and salter current flows into the Baltic through the Sound. Regular tides in the Baltic are imperceptible; but the waters occasionally rise more than 3 ft. above their usual level from some unknown cause—possibly from subterranean oscillations in its bed, or from changes of atmospheric pressure.

The *Black Sea,* which penetrates deeply into the continent, has, together with the Sea of Azov, an area of 172,505 sq. m.: it was at a remote period probably united with the Caspian Lake, their waters having covered all the steppe of Astrakhan. It receives some of the largest European rivers, and drains about 950,000 sq. m., consequently its waters are brackish and freeze on its northern shores in winter. It is very deep, no bottom having been reached in some places at 960 ft.; on the melting of the snow, such a body of water is poured into it by the great European rivers as to produce a rapid current, which sets along the western shore from the mouth of the Dneiper to the Bosphorus. The *Sea of Azov* may almost be considered as the estuary of the Don, notwithstanding its considerable extent of upwards of 13,000 sq. m. Its current is produced by the influx of that great river: its greatest depth is 40 ft., shoaling gradually, at the rate of about 1 ft. per mile, from the centre to the coasts.

Of all the branches of the Atlantic that enter deeply into the centre of the continent, the *Mediterranean* is the largest and most important, covering with its dark blue waters nearly 1,000,000 sq. m. Situated in a comparatively low latitude, exposed to the heat of the African deserts on the S., and sheltered on the N. by the high land of Southern Europe, the evaporation is great; on that account the water of the Mediterranean is salter than that of the ocean, and for the same reason the temperature at its surface is higher than that of the Atlantic in the same latitude;[1] it does not decrease so rapidly downwards as in tropical seas, and it becomes constant at depths of from 340 to 1000 fathoms, according to the situations.[2] Although its own river domain is only 250,000 sq. m., the constant current that sets in through the Dardanelles brings a

[1] Mean temperature of the Mediterranean, 67°·3
" " " Atlantic in the same lat., 67°·1.

[2] It may be regarded as a general rule that the temperature of all inland seas, at great depths, represents nearly the mean temperature of the earth in the latitudes where they are situated.

great part of the drainage of the Black Sea, so that it is really fed by the melted snow and rivers from the Caucasus, the mountains of Asia Minor and Abyssinia, the Atlas, and the Alps. The quantity of water that flows into the Mediterranean from the Atlantic by the superficial current in the Strait of Gibraltar escapes by evaporation.

The surface of the Mediterranean has the same level with the Red Sea,[1] and there was therefore no insuperable difficulty in cutting a ship canal from Lake Menzaleh to the Red Sea at Suez. Its actual width, over the greater part of its length, does not permit of two vessels passing or crossing each other in the Canal itself; but there are numerous sidings, by which vessels are enabled to cross one another, and the passage is quickened. On March 3, 1876, 33 large vessels were traversing the Canal simultaneously, some from Port Said and others from Suez. Vessels measuring 430 ft. in length and drawing 25 ft. 9 in. of water have passed safely through the Canal. (See also pp. 86 and 87.)

The Mediterranean is divided into two basins by a shallow plateau that runs from Cape Bon on the African coast to the S. and W. coasts of Sicily, the depth varying from 7 to 240 fathoms. On each side of this ridge the water is exceedingly deep. In the Strait of Gibraltar the greatest depth does not exceed 450 fathoms; but E. of this the depth increases considerably in some places — between Algiers and Toulon to 1600 fathoms. The soundings executed for laying down the submarine telegraph cable between Sardinia and the coast of Africa gave still greater depths. E. of the meridian of Malta commences the second deep basin, which extends uninterruptedly to the coast of Syria, in the midst of which rises abruptly the Island of Candia. From the soundings executed by two of our most distinguished naval surveyors, Captains Maunsell and Spratt, the greatest depth between the 17th and 19th meridians E. of Greenwich is 2170 fathoms; and on a line between Alexandria and Rhodes, 1600. At Nice, within a few yards of the shore, it is nearly 700 fathoms deep. This sea is not absolutely without tides; in the Adriatic they rise 5 ft. in the port of Venice, at the great Syrtis 5 ft. at new and full moon, at Naples about 12 inches, but in most other places they are scarcely perceptible. The surface is traversed by various currents, two of which, opposing one another, occasion the celebrated whirlpool of Charybdis, the terrors of which were much diminished by the earthquake of 1783. Its bed is subject to violent

[1] The surveys executed for the maritime canal between the Mediterranean and Suez showed that the difference of level between the two seas, if any, is very trifling.

volcanic paroxysms, and its surface is studded with islands of all sizes, from the magnificent kingdom of Sicily to mere barren rocks, some actively volcanic, others of volcanic formation, and many of the secondary geological period. Various parts of its coasts are in a state of great instability; in some places they have sunk down and risen again more than once within the historical period; but these are produced by local causes and are not general.

In the *Caribbean Sea* and the *Mexican Gulf* the temperature is about 83°·5 Fahr., while the Atlantic Ocean in the same latitude is not above 77° or 79°. Of that huge mass of water, partially separated from the Atlantic by a long line of islands and banks, the Caribbean Sea is the largest; it is as long from E. to W. as the distance between Great Britain and Newfoundland, and occupies 1,000,000 sq. m. Its depth in many places is very great, and its water is limpid. The *Gulf of Mexico*, fed by the Mississippi, one of the greatest of rivers, is more than half its size, or about 800,000 sq. m. so that the whole forms a sea of great magnitude. Its shores, and the shores of the numerous islands, are dangerous from shoals and coral reefs, but the interior of these seas is not. The trade winds prevail there; these seas are also subject to severe northern gales, and some parts of them are occasionally visited by tremendous hurricanes.

The accurate surveys undertaken for the railroad across the isthmus have shown that there is no other difference of level between the Atlantic and Pacific than that depending on the different times of high and low water, produced by the tides on the eastern and western shores.

As the Pacific does not penetrate the land in the same manner that the Atlantic does the continent of Europe, there are fewer great gulfs, or internal seas. Of the latter, the *Sea of Okhotsk* is the most extensive.

The *Red Sea* and the *Persian Gulf* are joined to the Indian Ocean by very narrow straits. The physical geography of the Red Sea is better known, and is of more importance since it has become the most direct highway to our eastern possessions. Separating Africa from Arabia, it extends in a N.E. direction for 1140 m. from the Strait of Babel-Mandeb to the Isthmus of Suez. Its greatest breadth is 230 m., but it is only 72 m. across where the peninsula of Sinai causes it to bifurcate into two elongated gulfs. Its greatest ascertained depth exceeds 1000 fathoms. The *Gulf of Suez* is 167 m. long, its greatest breadth is 30 m., but at its mouth it is only 17 from shore to shore. On an average it is only 22 fathoms deep, but in some places it is as much as 50 fathoms.

The *Gulf of Akabá* is not so large, being 100 m. long and 16 m.

across. It is much deeper, no bottom having been found with a line of 200 fathoms in some places; its general depth is 120 fathoms.

The *Strait of Babel-Mandeb* is divided by the Island of Perim, which has an excellent roadstead, where a fleet might lie in safety under shelter of volcanic cliffs. The wider channel is 13 m. across, with a depth of 100 fathoms in the middle. The ships from Aden prefer the lesser, which is only a mile and three quarters broad, but in mid-channel there are 30 fathoms water with a sandy bottom up to both shores, so it may be passed at all times of the tide. The *Gulf of Aden* is a funnel shaped estuary 900 m. long and nearly 200 across from the N.W. point of Africa to the Arabian shore; the central channel deep, shoaling to the shores, along which the water is shallow.

Scarcely any rain falls in the Red Sea, and no fresh water enters it; hence, by excessive evaporation in that dry region and low latitude, it would by this time have been evaporated and converted into one mass of solid salt, were it not that as fast as salt water is brought in from the ocean by the upper currents it is carried out again by those beneath. Dr. Buist computed that 165 cubic m. of water are annually dissipated in vapour from the Red Sea, all of which is replaced by surface currents from the ocean, while the brine resulting from this excessive evaporation, by its specific gravity, sinks to the bottom and flows out as an under current; this exchange is so constant and so great that he considered it more than probable that the Red Sea changes the entire amount of its waters at least once a year.

It is an invariable law when seas of different densities are connected that an exchange of water must take place, a salt and dense under current, and a less salt and consequently lighter surface current, flowing in an opposite direction.

The summer monsoon is S.E. in the region of the Red Sea, thus blowing down its axis for 4 months, while during the rest of the year the wind is from the N.W. The water of this sea is extremely pure and transparent, of an intense blue, changing to greenish blue, bluish green, and green, according as the coral, which is mostly white, lies near the surface.

The Red Sea and Arabian Gulf are covered with large patches, varying in size from a few yards to some square miles, of an intensely blood red colour, derived from animalculæ, which are particularly abundant in spring.[1]

Almost all the internal seas on the eastern coasts of Asia, except

[1] Dr. Buist, of Bombay, on the 'Physical Geography of the Red Sea,' in 'Journal of Geographical Society of London.'

the Yellow Sea, are great gulfs shut in by islands, like the Caribbean Sea and the Gulf of Mexico, such as the China Sea, the seas of Japan and of Okhotsk.

The set of the great oceanic currents has scooped out and indented the southern and eastern coasts of the Asiatic continent into enormous bays and gulfs, and has separated large portions of the land, which now remain as islands—a process which probably has been increased by the submarine fires extending along the eastern coast from the equator nearly to the Arctic Circle.

The perpetual agitation of the ocean by winds, tides, and currents is continually, but slowly, changing the form and position of the land—steadily producing those vicissitudes on the surface of the earth to which it has always been subject, and to which it will assuredly be liable in all succeeding ages.

CHAPTER XIX.

RIVERS.

§. 1. **Origin of Springs, and their temperatures.**—The invisible vapour which rises from the land and water ascends in the atmosphere till it is condensed by the cold into clouds, which restore it again to the earth in the form of rain, hail, and snow; hence there is probably not a drop of water on the earth's surface that has not been borne on the wings of the wind. Part of this moisture restored to the earth is re-absorbed by the air, part supplies the wants of animal and vegetable life, a portion is carried off by the streams, and the remaining part penetrates through porous soils till it arrives at a stratum impervious to water, where it accumulates in subterranean lakes, often of great extent. The mountains receive the greatest portion of the aërial moisture, and from the many alternations of permeable and impermeable strata they contain, a complete system of reservoirs is formed in them; and these, continually overflowing form perennial springs at different elevations which uniting and running down their sides, form the sources of rivers. A great portion of the water at these high levels penetrates the earth till it comes to an impermeable stratum below the plains, where it collects in sheets, or nappes, and is forced by hydraulic pressure to rise in springs through openings in the ground to the surface. In this manner the water which falls on hills and mountains is carried through highly inclined strata to great depths, and even below the bed of the ocean, in many parts of which there

exist, from this cause, springs of fresh water. In boring *Artesian*[1] wells the water often rushes up with such impetuosity by the hydrostatic pressure as to form jets 40 or 50 ft. high. In this operation several successive reservoirs have been met with; at St. Ouen, near Paris, five sheets of water were found; that in the first four not being good, the operation was continued to a greater depth; it consists merely in boring a hole of small diameter and lining it with a metallic tube. It rarely happens that water may not be procured in this way; and as the substratum in many parts of deserts is an argillaceous marl, it is probable that Artesian wells might be bored with success in the most arid regions. This has of late years been verified to great advantage in Algeria, where Artesian wells have brought fertility to districts hitherto arid and uncultivated.

A spring will be intermittent when it issues from an opening in the side of a reservoir fed from above, if the supply be not equal to the waste, for the water will sink below the opening and the spring will stop till the reservoir is replenished. Few springs give the same quantity of water at all times, those near the surface depending for their supply on the water that percolates the surface; they also vary much in the quantity of foreign matter they contain. Mountain springs are generally very pure; the carbonic acid gas almost always found in them escapes into the atmosphere, and their earthy matter is deposited as they run along; so that river water from such sources is soft, while wells and springs in the plains are hard and more or less mineral.

Springs acquire their temperature from that of the strata through which they pass; mountain springs are cold, but if the water has penetrated deep into the earth it acquires a temperature depending on that circumstance.

The temperature of the surface of the earth varies with the seasons to a certain depth, where it becomes permanent and for the most part equal to the mean annual temperature of the air above. It is evident that the depth at which this stratum of invariable temperature lies must vary with the latitude. At the equator the effect of the seasons is imperceptible at the depth of a foot below the surface: between the 40th and 52nd parallels the temperature of the ground in Europe is constant at the depth of from 55 to 60 ft.: and in the high Arctic regions the soil is perpetually frozen a foot below the surface. Now, in every part of the world where experiments have been made the temperature of the earth increases with the depth below the constant stratum

---

[1] *Artesian wells* are so called from their having been first used in the French province of *Artois*.

at the rate of 1° Fahr. for every 50 or 60 ft. of perpendicular depth; hence, should the increase continue to follow the same ratio, even granite must be in fusion at little more than five miles below the surface. In Siberia the stratum of frozen earth is some hundred feet thick, but below that the increase of heat with the depth is three times as rapid as in Europe. The temperature of springs must therefore depend on the depth to which the water has penetrated before it has been forced to the surface, either by the hydrostatic pressure of water at higher levels or by steam. If it never descends below the stratum of invariable temperature, the heat of the source will vary with the seasons, more or less, according to the depth below the surface: should the water come from the constant stratum itself, its temperature will be invariable; and if from below it, the heat will be increased in proportion to the depth to which it has penetrated. Thus, there may be hot and even boiling springs hundreds of miles distant from volcanic action and volcanic strata, of which there are many examples, though they are more frequent in volcanic countries and in those subject to earthquakes. The temperature of hot springs is very constant and that of boiling springs has remained unchanged for ages; shocks of earthquakes sometimes affect their temperature, and have even stopped them altogether. Jets of steam of high tension are frequent in volcanic countries, as in Iceland.

Water both hot and cold dissolves and combines with many of the mineral substances it meets with in the earth, and comes to the surface from great depths as medicinal springs, containing various chemical ingredients. So numerous are they that in the Austrian dominions alone there are 1500; and few countries of any extent are destitute of them. They contain hydro-sulphuric and carbonic acids, sulphur, iron, magnesia, and other substances. Boiling springs deposit silex, as in Iceland and in the Azores; and others of lower temperature deposit carbonate of lime in great quantities all over the world. Springs of pure brine are rare; those in Cheshire are rich in salt, and have flowed unchanged 1000 years, a proof of the tranquil state of that part of the globe. Many substances that lie beyond our reach are brought to the surface by springs, such as naphtha, petroleum, and boracic acid; petroleum is abundant in Persia; numberless springs and lakes of it surround some parts of the Caspian Sea, and the oil springs of Pennsylvania yield more than 1,000,000 barrels of crude oil per annum. Boracic acid, originally a gaseous emanation, is almost peculiar to Tuscany; it is found also in the Western Himalaya, and in combination with soda in some parts of Tibet.

§ 2. **Rivers** have had a greater influence on the location and fortunes of the human race than almost any other physical cause,

and since their velocity has been overcome by steam navigation they have become the highway of nations.

They frequently rise in lakes which they unite with the sea; in other instances they spring from small elevations in the plains, from perennial sources in the mountains, alpine lakes, melted snow and glaciers; but the everlasting storehouses of the mightiest floods are the ice clad mountains of table-lands.

Rivers, in descending the mountains and traversing the plains, are constantly increased by tributaries, till at last they flow into the ocean, their ultimate destination and remote origin. 'All rivers run into the sea, yet the sea is not full,' because it gives in evaporation an equivalent for what it receives.

The Atlantic, the Arctic, and the Pacific Oceans are directly or indirectly the recipients of all the rivers; therefore their basins are bounded by the principal watersheds of the continents; for the *basin of a sea or ocean* does not mean only the bed actually occupied by the water, but comprehends also all the land drained by the rivers which fall into it, and is bounded by an imaginary line passing through all their sources. These lines generally run through the elevated parts of a country that divide the streams which flow in one direction from those that flow in another. But the watershed does not coincide in all cases with mountain crests of great elevation, as the mere convexity of a plain is often sufficient to throw the streams into different directions.

From the peculiar structure of the highlands and mountain chains, by far the greater number of important rivers on the globe flow into the ocean in an easterly direction, those which flow to the S. and N. being the next in size, while those that flow in a westerly direction are comparatively small and unimportant.

The course of every river is changed when it passes from one geological formation to another, or by dislocations of the strata: the sudden deviations in their directions are generally owing to the latter circumstance.

None of the European rivers flowing directly into the Atlantic exceed the fourth or fifth magnitude, except the Rhine; the rest of the principal streams reach it indirectly through the Baltic, the Black Sea, and the Mediterranean. It nevertheless receives nearly half the waters of the old continent and almost all of the new, because the Andes and Rocky Mountains which form the watershed of the American continent lie along its western side, and the rivers which rise on their western slopes flow to the E., whilst those of the Alleghanies are tributaries to the Mississippi, which comes indirectly into the Atlantic by the Gulf of Mexico.

The Arctic Ocean drains the high northern latitudes of America, and receives those great Siberian rivers that originate in the

Altaï range from the Steppe of the Kirghiz to the extremity of Kamtschatka, as well as the very inferior streams of North European Russia. The running waters of the rest of the world flow into the Pacific. The Caspian and Lake Aral are mere salt water lakes, which receive rivers, but emit none. However, nearly one half of all the running water in Europe falls into the Black Sea and the Caspian.

Mountain torrents gradually lose velocity in their descent to the low lands by friction, and when they enter the plains their course becomes still more gentle and their depth greater. A slope of one foot in 200 prevents a river from being navigable, and a greater inclination forms a *rapid* or *cataract.* The speed, however, does not depend entirely upon the slope, but also upon the height of the source of the river, and the pressure of the body of water in the upper part of its course; consequently, under the same circumstances, large rivers run faster than small, but in each individual stream the velocity is perpetually varying with the form of the banks, the winding of the course, and the changes in the width of the channel. The Rhone, one of the swiftest of European rivers, has a declivity of one foot in 2624, and flows at the rate of 120 ft. in a minute; the sluggish rivers in Flanders have only one half that velocity. The Danube, the Tigris, and the Indus are among the most rapid of the large rivers. In flat countries rivers are generally more meandering, and thus they afford a greater amount of irrigation; the windings of the Vistula are nearly equal to nine tenths of its direct course from its source to its mouth.

When one river falls into another, the depth and velocity are increased, but not always proportionately to the width of the channel, which sometimes even becomes less, as at the junction of the Ohio with the Mississippi. When the angle of junction is very obtuse, and the velocity of the tributary stream great, it sometimes forces the water of its primary to recede a short distance. The Arve, swollen by a freshet, occasionally drives the water of the Rhone back into the Lake of Geneva; and it once happened that the force was so great as to make the mill wheels revolve in a contrary direction.

Streams sometimes suddenly disappear, and after flowing underground to some distance reappear at the surface, as in Derbyshire. Instances have occurred of rivers suddenly stopping in their courses for some hours and leaving their channels dry. On November 26, 1838, the water failed so completely in the Clyde, Nith, and Teviot, that the mills were stopped 8 hours in the lower part of their streams. The cause was the coincidence of a gale of wind and a strong frost, which congealed the water near their sources. Exactly the contrary happens in the Siberian rivers, which flow from S. to N. over so many hundreds of miles; the upper parts

are thawed while the lower are still frozen, and the water, not finding an outlet, inundates the country.

The alluvial soil carried down by streams is gradually deposited as their velocity diminishes; and if they are subject to inundations, and the coast is flat, it forms *deltas* [1] at their mouths; there they generally divide into branches, which often join again, or are united by transverse channels, so that a labyrinth of streams and islands is formed. Deltas are sometimes found in the interior of the continents at the junction of rivers, exactly similar to those in the ocean, though less extensive: deltas are said to be *maritime*, *lacustrine*, or *fluviatile*, according as the stream that forms them falls into the sea, a lake, or another river.

Tides flow up some rivers to a great distance, and to a height above that of their level in the sea: the tide is perceptible in the river Amazon 576 m. from its mouth, and it ascends 255 m. in the Orinoco.

In the temperate zones rivers are subject to floods from autumnal rains, and the melting of the snow, especially on mountain ranges. The Po, *e.g.*, spreads desolation far and wide over the plains of Lombardy; but these torrents are as variable in their recurrence and extent as the climate which produces them. The inundations of the rivers of the torrid zone, on the contrary, occur with a regularity peculiar to a region in which meteoric phenomena are uniform in all their changes. These floods are due to the periodical rains, which in tropical countries follow the cessation of the trade winds after the vernal equinox and at the turn of the monsoons, and are thus dependent on the declination of the sun, the immediate cause of all these variations. The melting of the snow, no doubt, adds greatly to the floods of the tropical rivers which rise in high mountain chains, but it is only an accessory circumstance; for although the snow water from the Himalayas swells the streams considerably before the rains begin yet the principal effect is owing to the latter, as the southern face of these mountains is not beyond the influence of the monsoon, and the consequent periodical rains, which prevail also all over the plains of India that are traversed by the great rivers and their tributaries.

Under like circumstances the floods of rivers whose sources are in the same latitude take place at the same season; but the periods of the inundations of rivers on one side of the equator are exactly the contrary of what they are in rivers on the other side of it, on account of the declination of the sun. The flood in the Orinoco is at its greatest height in the month of August, while that

---

[1] A *delta* is a triangular piece of land; it is so called from its likeness to a Δ (Delta) the fourth letter of the Greek alphabet.

of the river Amazon, S. of the equinoctial line, is at its greatest elevation in May. The commencement and end of the annual inundations in each river depend upon the average time of the beginning, and on the duration of the rains in the latitudes traversed by its affluents. The periods of the floods in such rivers as run towards the equator are different from those flowing in an opposite direction; and as the rise requires time to travel, it happens at regular but different periods in various parts of the same river, if very long. The height to which the water rises in the annual floods depends upon the nature of the country, but it is wonderfully constant in each individual river where the course is long; for the inequality in the quantity of rain in a district drained by any of its affluents is imperceptible in the general flood, and thus the quantity of water carried down is a measure of the mean humidity of the whole country comprised in its basin from year to year. By the admirable arrangement of these periodical inundations, the fresh soil of the mountains, borne down by the water, enriches countries far remote from their source. The waters from the high lands on the northern border of the great plateau, and of Abyssinia, have fertilised the banks of the Nile through a distance of 2500 m. for thousands of years.

When rivers rise in mountains, water communication between them in the upper parts of their course is impossible; but when they descend to the plains, or rise in the low lands, the boundaries between the countries drained by them become low, and the different systems may be united by canals. It sometimes happens in extensive and very level plains that the tributaries of the principal streams either unite or are connected by a natural canal by which a communication is formed between the two basins—a circumstance advantageous to the navigation and commerce of both especially where the junction takes place far inland, as between the Orinoco and Amazon in the interior of South America. The Rio Negro, one of the largest affluents of the latter, is united to the Upper Orinoco, in the plains of Esmeralda, by the Cassiquiare —a stream as large as the Rhine, with a velocity of 12 ft. per second. Humboldt observes that the Orinoco, sending a branch to the Amazon, is, with regard to distance, as if the Rhine should send one to the Seine or Loire. At some future period this junction will be of great importance. These bifurcations are frequent in the deltas of rivers, but very rare in the interior of continents.

§ 3. **Hydraulic system of Europe.**—The hydraulic system of Europe is eminently favourable to inland navigation, small as the rivers are in comparison with those of other parts of the world; but the flatness of the great plain, and the lowness of its water-

shed are very favourable to the construction of canals. In the west, however, the Alps and German mountains divide the waters that flow to the Atlantic on one side, and to the Mediterranean and Black Sea on the other; but in the eastern parts of Europe the division of the waters is merely a more elevated ridge of the plain itself, for in all plains such undulations exist, though often imperceptible to the eye. This watershed begins on the northern declivity of the Carpathian Mountains about the 23rd meridian, in a low range of hills running between the sources of the Dnieper and the tributaries of the Vistula, from whence it winds in a tortuous course along the plain to the Valdai table-land, which is its highest point, 1200 ft. above the sea; it then declines northward towards Onega, about the 60th parallel, and lastly turns in a very serpentine line to the sources of the Kama in the Ural Mountains near 62° N. lat. The waters N. of this line run into the Baltic and White Seas, and on the S. of it, into the Black Sea, and the Caspian.

Thus Europe is divided into two principal hydraulic systems; but since the basin of a river comprehends all the plains and valleys drained by it and its tributaries from its source to the sea, each country is subdivided into as many natural divisions or basins as it has primary rivers, and these generally comprise all the rich and habitable parts of the earth, and are the principal centres of civilisation, or are capable of becoming so.

The streams to the N. of the general watershed are very numerous; those to the S. are of greater magnitude. The systems of the *Volga* and *Danube* are the most extensive in Europe; the former has a basin comprising 604,000 sq. m., and is navigable throughout the greater part of its course. It rises in a small lake on the slopes of the Valdai table-land, 750 ft. above the level of the ocean, and falls into the Caspian, which is 86 ft. below the level of the Black Sea, so that it has a fall of 836 ft. in a course of 2300 m. It carries to the Caspian one seventh of all the river water of Europe.

The *Danube* drains 308,500 sq. m., and receives 60 navigable tributaries. Its quantity of water is nearly as great as that of all the rivers that empty themselves into the Black Sea taken together. Its direct course is 1000 m., its meandering line is 1760. It rises in the Black Forest at an elevation of 2980 ft. above the level of the sea, so that it has considerable velocity, which, as well as rocks and rapids, impedes its navigation in many places, but it is navigable downwards, through Austria, for 600 m., to New Orsova, from whence it flows in a gentle current to the Black Sea. The commercial importance of these two rivers is much increased by their flowing into inland seas. By canals between the Volga and the rivers N. of the watershed, the Baltic and White Seas are connected with the Black Sea and the Caspian; and the Baltic and

Black Sea are also connected by a canal between the Don and the Dnieper. Altogether, the water system of Russia is the most extensive in Europe.

The whole of Holland is a collection of deltoid islands, formed by the Rhine, the Meuse, and the Scheldt—a structure very favourable to commerce, and which has facilitated an extensive internal navigation. By the completion of the North Sea Canal, which took place in November, 1876, a short and direct route has been opened between the coast and Amsterdam; so that that city may now be reached by the largest steamers in as many hours as they have hitherto taken days. The Mediterranean is already connected with the North Sea by the canal which runs from the Rhone to the Rhine; and this noble system, extended over the whole of France by 7591 m. of inland navigation, has conduced much to the prosperous state of that great country.

Many navigable streams rise in the Spanish mountains; of these the *Tagus* has depth enough for the largest ships as high as Lisbon. Its actual course is 550 m., but its direct one is much less. In point of magnitude, however, the Spanish rivers are of inferior order, but canals have rendered them beneficial to the country. Italy is less favoured in her rivers, which only admit vessels of small burthen; those on the N. are by much the most important, especially the Po and its tributaries, which by canals connect Venice and Milan with various fertile provinces of Northern Italy; but whatever advantages nature has afforded to the Italian States have been improved by able engineers, both in ancient and modern times.

The application of the science of hydraulics to rivers took its rise in Northern Italy, where it has been carried to such perfection in some points that China is the only country which can vie with it in the practice of irrigation. The lock on canals was in use in Lombardy as early as the thirteenth century, and in the end of the fifteenth it was applied to two canals which unite the Ticino and the Adda, by that great artist and philosopher Leonardo da Vinci, about the same time that he introduced the use of the lock into France.[1]

Various circumstances combine to make the British rivers more useful than many others of greater magnitude. The larger streams are not encumbered with rocks or rapids; they all run into branches of the Atlantic; the tides flow up their channels to a considerable

---

[1] Leonardo da Vinci was appointed Director of Hydraulic Operations in Lombardy by the Duke of Milan, and during the time he was painting the 'Last Supper' he completed the Martesana Canal, extending from the Adda to Milan, and improved the course of the latter river from where it emerges from the Lake of Como to the Po. By means of the Naviglio Grande, the Martesana Canal establishes a water communication between the Adda and the Ticino, the Lakes of Como and Maggiore.

distance; and above all, though short in their course, they end in wide estuaries and sounds, capable of containing whole navies—a circumstance that gives an importance to streams otherwise insignificant when compared with the great rivers of either the old or the new continent.

The *Thames*, whose basin is only 4800 sq. m., and whose length is but 215, of which, however, 160 are navigable, spreads its influence over the remotest parts of the earth; its depth is sufficient to admit large vessels even up to London, and throughout its navigable course a continued forest of masts displays the flags of every nation: on its banks, which are in a highly cultivated state, is the seat of the highest civilisation, moral and political. Local circumstances have undoubtedly been favourable to this superior development, but the earnest and energetic temperament of the Saxon races has rendered these natural advantages of position much more available. The same may be said of other rivers in the British islands, where commercial enterprise and activity vie with those on the Thames. There are 2790 m. of navigable canals in Britain, and including rivers, 5430 m. of inland navigation which, in comparison with the area of the country, is very great; it is even said that no part of England is more than 15 m. distant from water communication.

On the whole, Europe is fortunate with regard to its water systems, and its inhabitants are for the most part alive to the bounties which Providence in this respect has bestowed upon them.

§ 4. **African Rivers.**—In Africa the tropical climate and the extremes of aridity and moisture give a totally different character to its rivers. The most southerly point is comparatively destitute of them, and those that do exist are of inferior size, except the Gariep, or Orange River, which has a long course on the table-land, but is nowhere navigable. In comparatively level tracts of no great elevation in the centre of the table-land, rise those innumerable streams which fill the plateau of South Africa with a perfect maze of large rivers, of which the *Zambesi* or *Leambye* is the main artery. That river is now known to be one of the greatest of the continent. It drains an area of 568,000 sq. m. It takes its rise in the Gilolo hills, and is joined by the Leeba at the northern extremity of the Barotse valley, about 800 m. from Loanda. It then flows from N. to S. for 240 m., where it is joined by the noble deep river Chobe, in 18° 17′ S. lat. and 23° 50′ E. long. The first 100 m. is through the Barotse valley, a grazing country, with the towns raised on mounds on account of the annual inundations. After this the river is extremely beautiful and often a mile broad, with many islands covered with the richest vegetation. Before its junction with the Chobe its bed becomes rocky as well as its banks.

which are undulating, and the trees send down roots from their branches like the banyan. The united stream flows to the E., and in 17° 57′ S. lat. and 26° 6′ E. long. forms one of the most magnificent cataracts known. The river, here 1000 yards broad, drops into a deep narrow chasm in the basaltic rock, not more than 25 yards wide, and 300 ft. deep, finding an outlet near one extremity of the cleft, and pursuing its rapid course through a succession of similar ravines lower down. The effect of its sudden contraction and fall is in the highest degree sublime, and from the point from which Dr. Livingstone saw it, appalling, for he got a native of sufficient nerve to paddle a canoe to an islet immediately above the fall: the columns of vapour rushing up for 300 or 400 ft. form dense clouds, whence the name of 'Mosioatunya,' or the 'smoke-resounding falls.' When Dr. Livingstone saw this fall the waters were low, but during the inundations, when the river flows between banks many miles wide and still forces itself through the same narrow space, it must be terrifically magnificent beyond description; at these times the columns of spray may be seen, and the roar heard, 10 or 12 m. off.

After entering this chasm the river changes its course, foams and rages through a narrow channel amongst tree covered hills, and then emerging from its confines spreads out again and flows to the N.N.E., in a broad placid stream, to its junction with the Kafue, a large fine river coming from the W.; from that the combined stream runs in a bending line eastward to its confluence with the Mutu, or Quilimane, at the head of its delta, where it is three quarters of a mile broad. There is a great body of water in it during the rains, and in the dry season it is shallow, except in its winding mid-channel. Its delta is 300 m. long, and as large as Scotland. It would be vain to mention all the rivers that flow into the Zambesi they are so numerous and complicated; but the Shiré is too important to be omitted. It rises in Lake Nyassa, and in the middle of its course of 200 m., from so high an altitude to the Zambesi, forms a series of cataracts 40 m. long.

The river next in importance on the East African coast is the *Limpopo*, or *Krokodil River*, a large stream, which rises in, and forms the N.W. and N. frontiers of, the Trans Vaal Republic. Turning S. by E. it enters the Indian Ocean under the local name of the Inhampura, a little to the N. of Delagoa Bay. Its principal tributary is the Olifant or Lipaluli which it receives from the W. in 24° 10′ S. lat. The shallowness of the water in the lower part, and the formidable sandbanks across the mouth of the river will, unfortunately, prevent this fine river, which has a course of nearly 900 m., through a varied and productive region, from ever becoming useful as a channel of communication.

The rivers which flow to the Atlantic, and fertilise the luxuriant maritime plains of Benguela, Congo, Angola, and Loango, have their sources on the table-land. The *Congo* is considered, since the explorations of Lieutenant Cameron (1873–75), to be one and the same river with, and therefore to have for its head waters, the Chambeze and its tributaries. Livingstone traced the Chambeze into Lake Bangweolo, thence into Moero as the Luapula, and out of that lake as the Lualaba, subsequently taking the name of the Ugarrowwa, to the N. Although Lieutenant Cameron states that the river leaving Moero is not the Lualaba, but probably the Luvwa, and that the Lualaba is a W. branch which joins the Luvwa near the 6th parallel N. lat., there seems to be little reason to doubt that these waters are connected with the Congo, and form part of one of the most gigantic river systems in the world. In its lower course the Congo is 5 or 6 m. broad, studded with islands, and very deep at its mouth. It is navigable for 160 m. above the sea up to Ilalla, where the ascending tide is stopped by cataracts.[1]

Farther to the N. the *Ogowé,* a noble river, probably not inferior to the Zambesi, is formed by the junction of two great streams, the Okanda, probably the main stream, coming from the unknown region to the N.E., and the Ngunyai, discovered by the adventurous explorer Du Chaillu, coming from the S.E. The Ogowé and Okanda are navigable in the rainy season as far as they have been explored, and their waters at the mouth form a common delta with the Fernand Vaz. The Nazareth and Mexias, hitherto believed to be separate rivers, are merely two of the mouths of this system of rivers. Dr. Barth suspected the Ogowé to be the lower part of that river which was described to him as running westward many days' journey S. from Wadai, and he believed there was a vast field for future discovery along the great Okanda branch of the Ogowé.

The mountainous edge of the table-land, with its terminal projections, Senegambia and Abyssinia, are the principal sources of the great streams of Central Africa. Various rivers have their origin in these elevated regions, of which the Nile and the Niger yield in size only to some of the great Asiatic and American rivers. In importance and historical interest the Nile is inferior to none.

Two large rivers unite their streams to form the *Nile*—the Bahr el Abiad, or White Nile, and the Bahr el Asrak, or Blue Nile; but the latter is so far inferior to the Bahr el Abiad that it is now regarded as a tributary. Another great tributary, of which little was known until it was visited by Petherick, is the Bahr el Gazal, which, coming from a large level region to the W. and S.,

[1] 'Proceedings of the Royal Geographical Society of London, 1876.'

joins the White Nile in about 9° 30′ N. lat. The main stream was navigated as far as 4° 9′ N. lat., the point reached by the missionary Knoblecher, who could see the river for 30 m. farther coming from the S.W. In 1875 Signor Carlo Piazzia and Signor Gessi ascended the river with two barges laden with arms and munitions of war, from Dufle to Magungo, near the N.E. extremity of the Albert Nyanza, a part of the Nile previously unknown. Piazzia then followed the Somerset River to the Murchison Falls, a distance of 35 m., in his canoe. Thence to Foveira, about 63 m., the river forms an almost continuous series of cataracts.[1] The true sources of the Nile are still unknown.

The Abyssinian tributary of the Nile, known as the Bahr-el-Asrak, or Blue Nile, rises in Lake Tsána in Abyssinia; it bounds the kingdom of Abyssinia on the S.W., and then maintains a general N.W. direction till it joins the White Nile at Khartum. The Atbara, formed by the junction of the Goang and Takassie, is one of the principal tributaries of the Nile. The Takassie rises near the Wandatsch Pass, a little to the E. of Lalíbala, one of the most celebrated places in Abyssinia, remarkable for its churches hewn out of the solid rock; and the Tselari, which springs from Mount Biála, the N. extremity of the high land of Lasta which divides the head waters of the two branches. The united stream, after winding like the other rivers of this country, joins the Nile in 17° 30′ N. lat., the N. limit of the tropical rains.

The Abyssinian rivers in the upper part of their course are little more than muddy brooks in the dry season, but during the rains they inundate the plains. They have scooped deep ravines in the rocky surface of the table-lands; in emerging on the plains, they are at first only a few yards wide, but gradually increase to several miles; the streams form cataracts from 80 to more than 100 ft. high, and then continue to descend by a succession of falls and rapids, which decrease in height as they run northwards to join the main stream. The Takassie takes its name of 'The Terrible' from the impetuosity with which it rushes through the chasms and over the precipices of the mountains. The sediment brought down by this river, produced by attrition of the basaltic and other rocks, forms the fertilising mud of Egypt. It is swept down during the rainy season. In the dry season the Atbara is merely a string of stagnant pools; it is to the White Nile solely that is due the perennial flow of water which prevents Egypt from becoming a barren waste of sand; and the irrigating stream is derived from the lake reservoirs under the equator.

From the Atbara down to the Mediterranean, a distance of

[1] See 'Geographical Magazine' for December 1, 1876, p. 340.

1200 m., the *Nile* does not receive a single brook. The first part of that course is interrupted by cataracts, from the geological structure of the Nubian Desert, which consists of a succession of broad sterile terraces separated by ranges of rocks running E. and W. Over these the Nile falls in 9 or 10 cataracts, the last of which is at Syene in Upper Egypt. Most of them are only rapids where each successive fall of water is not a foot high. That they were higher at a former period has been shown to be probable by Dr. Lepsius, a traveller sent by the King of Prussia at the head of a mission to explore that country. He found a series of inscriptions on the rocks at Sennaar marking the height of the Nile at different periods; from which it appears that in that country the bed of the river had been 30 ft. higher than it is now.

Fifteen miles below Cairo, and 90 m. from the sea, the Nile separates into two branches, one of which, running in a northerly direction, enters the Mediterranean below Rosetta; the other enters the sea above Damietta; the delta between these two places has a sea coast of 187 m. The fall from the great cataract to the sea is about 2 inches in a mile.

The extent of the basin of the Nile is estimated at 900,000 sq. m. Excluding the southern lakes, it has an unusual form; it is wide in Ethiopia and Nubia, but for the greater part of a winding course of about 3600 m. it is merely a verdant line of beauty, suddenly and strongly contrasted with the dreary waste of the Red Desert in the midst of which it lies. Extending from the torrid, far into the temperate, zone its aspect is less varied than might have been expected, on account of the parched and showerless country it passes through. Nevertheless, from the great elevation of the sources of the river, the upper portion has a perpetual spring, though within a few degrees of the equator. At the foot of the table-land of Abyssinia the country is covered with dense tropical jungles, while the rest of the valley, covered by the detritus of the mountains for thousands of years, is fertile and luxuriant.

As the mean velocity of the Nile, when not flooded, is about $2\frac{1}{2}$ m. per hour, a particle of water would take $22\frac{1}{2}$ days to descend from the junction of the Takassie to the sea; hence the retardation of the annual inundations of the Nile in its course is a peculiarity of this river, owing to some unknown cause towards its origin which affects the whole stream. In Abyssinia and Sennaar the river begins to rise in April,[1] yet the flood is not perceptible at

[1] The April rains in Abyssinia are slight, and coincide with the passage of the sun in the prime vertical, and a partial rise of the Nile corresponding to them has been observed at Cairo; but the principal rains, the probable cause of the great rise in the waters of the Nile, take place at a later period in Enarea, and probably throughout all Ethiopia between 7° and 9° N.

Cairo till towards the summer solstice; it then continues to rise during nearly 100 days, and remains at its greatest height till the middle of October, when it begins to subside, and reaches its lowest point in April and May. The height of the flood in Upper Egypt varies from 30 to 35 ft.; at Cairo it is 23 ft., and in the northern part of the delta only 4 ft.

Anubis or Sirius, the Dog-star, was held in veneration by the Egyptians, from its supposed influence on the rising of the Nile. According to Champollion, the calendar of that extraordinary people commenced when the heliacal rising of that star coincided with the summer solstice—the time at which the Nile began to rise at Cairo. Now this coincidence, according to the most accurate calculation, took place about 3291 years B.C.; and as the rising of the river occurs at precisely the same time and in the same manner, it follows that the heat and periodical rains in Upper Ethiopia have not varied for 5000 years. In the time of Hipparchus the summer solstice was in the sign of Leo, and probably about that period the flowing of the fountains from the mouths of lions of basalt and granite was adopted as emblematical of the pouring forth of the floods of the Nile. The emblem is still common among the Egyptian monuments transported to Rome. Since then the signs of the Zodiac have retrograded more than 30 degrees.

The great African rivers the *Nile* and the *Niger* are dissimilar in almost every circumstance. The Nile, discharging its waters for ages into a sea the centre of commerce and civilisation, has been renowned by the earliest historians, sacred and profane, for the exuberant fertility of its banks, and for the learning and wisdom of the people who inhabited them, and on which they have left magnificent and imperishable monuments of their genius and power. Egypt was for ages the seat of science, and by the Red Sea it had intercourse with the most highly cultivated nations of the East from time immemorial. The Niger, on the contrary, though its rival in magnitude, and running through a country glowing with all the brilliancy of tropical vegetation, has ever been inhabited by barbarous or semi-barbarous tribes; and its course till lately was little known. In early ages, before the Pillars of Hercules had been passed, and indeed long afterwards, the Atlantic coast of Africa was an unknown region, and thus the flowing of the Niger into that lonely ocean kept the natives in their original rude state. Such are the effects of local circumstances on the intellectual advancement of mankind.

It rains there every day in September; and as the maximum rise of the Nile at Cairo is in October, these two phenomena are evidently connected.—*D'Abbadie.*

The sources of the *Niger*, *Joliba*, or *Quorra*, are supposed to be on the N. side of the Kong Mountains, in the country of Ganova, more than 2000 ft. above the level of the sea. From thence it runs N.E., and after passing through Lake Debo, makes a wide circuit in the plains of Soudan through 8 or 9 degrees of latitude; then bending round, it again approaches the Kong Mountains, at the distance of 1000 m. in a straight line from its source, and having threaded them flows across the low lands into the Gulf of Guinea. In the plains of Soudan it receives many very large affluents from the high land of Senegambia on the W.; and the Tchadda, on the E., a navigable river larger than itself, falls into it a little below Fundah, after a course of some hundred miles: thus the Niger probably affords an uninterrupted water communication from the Atlantic to the heart of Africa.[1] Long before emerging from the plains of Soudan it becomes a noble river with a placid stream, running at the rate of from 5 to 8 m. an hour, varying in breadth from 1 to 8 m. Its banks are studded with populous towns and villages, surrounded by groves of palm trees and cultivated fields.

This great river divides into 3 branches near the head of a delta which is equal in area to Ireland, intersected by navigable branches of the principal stream in every direction. The soil consists of a rich mould, and the vegetation is so rank that the trees seem to grow out of the water. The Nun, which is the principal or central branch, flows into the sea near Cape Formosa, and is that by which the brothers Lander descended. There are, however, 6 rivers which run into the Bight of Benin all communicating with the Niger and with one another. The *Old Calabar* is the most eastern; it flows through the Afra country coming from unknown sources, and is united to the Niger by a natural canal. The Niger throughout its long winding course lies entirely within the tropic of Cancer, and is consequently subject to periodical inundations which reach their greatest height in August, about 40 or 50 days after the summer solstice. The plains of Soudan are then covered with water and crowded by boats. These fertile regions are inaccessible to Europeans from the pernicious climate, and from the savage nature of many of the tribes.

The coast of Guinea, W. of the Niger, is watered by many streams which descend from the Kong Mountains, chief of which are the *Volta*, which has been recently explored (1875–76) as far as the famous city of Salagu or Saraha, by M. Bonnat,[2] the *Prah*, and the *Assinie*. From the table-land of Senegambia rise the *Rio Grande*, the *Gambia*, the *Senegal*, and other rivers of great size,

---

1 Captain W. Allen, R.N.

2 See 'Geographical Magazine' for November 1, 1876, p. 290.

and also many of an inferior order that fertilise the maritime plains on the Atlantic. Their navigable course is cut short by a chain of mountains which forms the escarpment of the high land, through which they force their way in rapids and cataracts. The *Gambia* rises near the source of the Rio Grande, and after a course of about 450 m. enters the Atlantic by many branches connected by natural channels, supposed at one time to be separate rivers. The *Senegal,* the largest river in this part of Africa, is about 850 m. long. It receives many tributaries in the upper part of its course; the lower part is full of islands. It drains two lakes, and is connected with the waters of the basin of the Gambia by the River Neriko.

CHAPTER XX.

ASIATIC RIVERS.

§ 1. **Rivers of Western Asia.**—The only river system of Western Asia is that of the *Euphrates* and *Tigris*, the basin of which covers an area of 250,000 sq. m., and includes the sites of Nineveh and Babylon the most famous cities of antiquity. Innumerable remains and inscriptions, the records of very remote times, have been discovered of late years, and bear testimony to the truth of some of the most interesting pages of sacred history. The *Euphrates* has its two chief ultimate sources in the Armenian Mountains, one at Domli, 25 m. N.E. of Erzeroum, the other in the Ala Dagh, near Mount Ararat. The two streams, called the Eastern and Western Euphrates, flow W. for 270 and 400 m. respectively, and meet at Kebban-Maden, near long. 39° E. The river thus formed is 120 yards broad, swift and deep, and, flowing S., forces its way through the Taurus and Anti-Taurus ranges into the plains of Mesopotamia. It then runs S.W., S., and S.E., to its junction with the Tigris, having traversed a course of more than 1850 m.

The *Tigris* rises in a small lake near the S.W. shore of Göldschyk Göl, and a little to the N.W. of Telek on the left bank of the Euphrates. In the mountains to the N. and W. of Diarbekr, and after receiving several tributaries from the high lands of Kúrdistán, it pierces the Taurus range about 100 m. above Mosul, from whence it descends in a tortuous course through the plain of ancient Assyria, receiving many streams from the Tyari Mountains, and, farther S., from those at Luristán. The country through which it flows is rich in corn fields, date groves, and forest trees. Near the city of Bagdad the Tigris and Euphrates approach to within 12 m. of each other, where they were once connected by

two great canals. From this point they run nearly parallel for more than 100 m., enclosing the plain of Babylon or Southern Mesopotamia—the modern Irak-Arabi. The two rivers unite at Kurnah and form one stream, the *Shat-ul-Arab*, which runs 150 m. before it falls into the Persian Gulf. The banks of the Tigris and Euphrates, once the seat of an extensive population, of art, civilisation, and industry, are now nearly deserted, covered with brushwood and grass, dependent on the rains alone for that luxuriant vegetation which, under an admirable system of irrigation, formerly covered them. The floods of the rivers are very regular in their rise and fall; beginning in March, they attain their greatest height in June. Excepting the two large centres of population, Bagdad and Mosul, the inhabitants consist of nomade Kurdish tribes. What remains of civilisation has taken refuge in the mountains of the ancient Chaldeans where the few traces of primitive and most ancient Christianity, under the misapplied denomination of Nestorian Christians, are to be found in the Tyari range.

The *Persian Gulf* may be navigated by steam all the year; the Euphrates only 8 months; this river might, however, afford easy intercourse with Eastern Asia, as it did in former times. The distance from Aleppo to Bombay by the Euphrates is 2870 m., of which 2700, from Bir to Bombay, are by water; in the time of our Queen Elizabeth this was the common route to India, and a fleet was then kept at Bir expressly for that navigation.

§ 2. **Rivers of Southern Asia.**—Seven rivers of the first magnitude descend from the S. side of the table-land of Eastern Asia and its mountain barriers, viz. the *Indus*, *Brahmaputra*, *Ganges*, *Irawadi*, *Salwen*, *Me Nam*, and the *Me Khong* or *Kambodia*, which, differing in origin, direction, and character, water the plains of Southern Asia and convey to the ocean a greater volume of water than all the rivers of the rest of the continent conjointly.

The *Indus*[1] has its ultimate sources a little to the N. of the Kailas Peaks, and within a few miles of the sources of the Sutlej and the Brahmaputra. The direction of both the Indus and the Brahmaputra lies parallel to the axis of the Himalaya till they reach its known extremities, where they descend rapidly and turn abruptly in their way to the plains of India. The main stream of the Indus is 750 m. long from its head, which is called the Lion's Mouth, about the 81st meridian E., to Acho, in Lower Balti. It receives, in 79° 45′ E. long., the Gartung-chu River, at which point its waters flow at an elevation of 13,000 ft. above the level of the sea. The gold district of Western Tibet lies a little to the E. of the mountain ranges

---

[1] *Indus* is the name of the native 'Sindu" or 'Sinde,='ocean,' or 'flood.'

which enclose the river valley. Running N.W., the Indus is joined near the 76th meridian by the Shyok which flows from the S. slope of the Karakoram range. At Acho, in Lower Balti, after a course of 200 m., the Tibetan Indus descends W. of the valley of Kashmir to the plain of the Panjab. According to Captain Strachey, the Tibetan Indus drains 47,000 sq. m. The greatest of its tributaries, the Sutlej, issues from the Lake Rakas in the Gangri valley, breaks through the Himalayas about the 75th meridian, and traverses the whole breadth of the chain in frightful chasms to the plains of the Panjab. Three tributaries—the Jhilám or Hydaspes, the Chenab or Acesines, and the Ravi or Hydraötes, all superior to the Rhone in size—flow from the S. face of the Himalayas, and with the Sutlej (anct. Hyphasis) join the Indus before it reaches Mittun; hence the name Panjab, 'the plain of the five rivers,' now one of the most valuable countries of our Eastern empire. From Mittun to the ocean the Indus does not receive a single tributary. The Kabul River, which rises near Ghazni, and is joined by a larger affluent from the southern declivities of the Hindu Kush, flows through picturesque but dangerous defiles, and joins the Indus at the town of Attock, and is the only tributary of any magnitude that enters it from the W.

The Indus is not well adapted for navigation; for 70 m. after it leaves the mountains the descent in a boat is dangerous, and it is only navigable for steam vessels of small draught; yet, from the fertility of the Panjab, and the near approach of its basin to that of the Ganges at the foot of the mountains, it has already become a valuable acquisition, because it commands the principal roads between Persia and India, one through Kabul and Peshawar, and the other from Herat through Kandahar. The delta of the Indus, formerly celebrated for its civilisation, has long been a desert; but from the luxuriance of the soil, and the change of political circumstances, it may again resume its pristine aspect. It is 60 m. long, and presents a line of 120 m. along the Arabian sea, where the river empties itself by many mouths, of which only 3 or 4 are navigable; one only can be entered by vessels of 50 tons, and all are liable to change. The tide ascends them with extraordinary rapidity for 75 m.; and so great is the quantity of mud carried by it, and the absorbing violence of the eddies, that a vessel wrecked on the coast was buried in sand and mud in two tides. The annual floods begin with the melting of the snow in the Himalayas towards the end of April, attain their greatest height in July, and end in September. The length of the Indus is 1800 m., and it drains an area of about 372,700 sq. m.

The double system of the *Ganges* and *Brahmaputra*, though draining opposite sides of the main chain of the Himalayas, enters

the sea by a common delta, and forms one of the most important river systems on the globe.

The *Ganges* flows at once in a very rapid stream not less than 40 yards across, from a huge cave in a perpendicular wall of ice at a distance of about three marches from the Temple of Gungutree, to which the Hindu pilgrims resort in great numbers. Mr. Elliot[1] says: 'The view from the glacier was perfectly amazing; beautiful or magnificent is no word for it—it was really quite astonishing. If you could fancy a bird's-eye view of all the mountains in the world in one cluster, and every one of them covered with snow, it would hardly give you an idea of the sight which presented itself.'

Many streams from the S. face of the Himalayas unite at Hardwar to form the great body of the river. The Ganges flows from thence in a S.E. direction through the plains of Bengal receiving in its course 19 or 20 tributaries, of which 12 are larger than the Rhine. About 220 m. in a direct line from the Bay of Bengal, into which it flows, the innumerable channels and branches into which it splits form an intricate maze over a delta twice as large as that of the Nile. The Ganges is 1514 m. long, and drains an area of 391,000 sq. m.

The *Brahmaputra* (='Son of Brahma'), a river superior in the volume of its waters to the Ganges, may be considered as the continuation of the Tsampu or river of Lhassa, which has its remotest sources near the 82° meridian E. in the glaciers of those mountains which skirt the S. shores of the Gunkyudcho Lake, at an elevation of upwards of 15,000 ft., and not far from the sources of the Indus and Sutlej. After watering the great longitudinal valley in the highlands of Tibet, descending from 15,000 to 11,400 ft. S. of Lhassa, it is said to bend to the S.E. between the 92nd and 93rd meridians, and is thought to cut through the Himalayas, between Iskardo and Attock; after which it receives several tributaries from the N.W. and N.E. Although much of its eastern course has not yet been explored, there is very little doubt that the river which cuts through the Himalayas and traverses Upper Assam is the Brahmaputra. In Upper Assam, the river forms several extensive channel islands, and receives some considerable affluents, of which the origin is unknown, though some are supposed to come from the table-land of Eastern Tibet. Before it enters the plains of Bengal, below Goyalpara, the Brahmaputra runs with rapidity and in great volume, and, after receiving the rivers of Bhutan and other streams, branches of it unite with those of the Ganges about 40 m. from the coast, but the two rivers enter the sea by different mouths, though they sometimes approach within 2 m. of one another. The length of the Brahmaputra is

[1] Mr. Elliot was one of the first persons who visited the mouth of the Ganges.

1800 m., or nearly the same as that of the Ganges; the volume of water discharged by it during the dry season is about 146,188 cubic ft. per second; the quantity discharged by the Ganges in the same time and under the same circumstances is only 80,000 cubic ft. In the perennial floods the quantity of water poured through the tributaries of the Brahmaputra from their snowy sources is incredible; the plains of Upper Assam are an entire sheet of water from June 15 to September 15, and there is no communication but by elevated causeways 8 or 10 ft. high; the two rivers, with their branches, lay the plain of Bengal under water for hundreds of miles annually. They begin first to swell from the melting of the snow on the mountains, but before their inferior streams overflow from that cause, all the lower parts of Bengal adjacent to the Ganges and Brahmaputra are under water from the swelling of these rivers by the rains. The increase is arrested before the middle of August by the cessation of the rains in the mountains, though they continue to fall longer on the plains. The delta is traversed in every direction by arms of the rivers. The Hugli branch, at all times navigable, passes Calcutta and Chandernagore; and the Hauringotta arm is also navigable, as well as the Ganges properly so called. The channels, however, are perpetually changing, from the strength of the current and the prodigious quantity of matter brought down from the high lands. The *Sunderbunds* are a congeries of forest-covered mud banks permeated by channels and lagoons lying between the water of the bay and the cultivated land of the Ganges delta. They are above 3000 sq. m. in extent, and the jungle which covers them is haunted by savage beasts of various kinds, but especially by tigers. The united rivers of the Ganges and Brahmaputra drain an area of 752,300 sq. m., and there is scarcely a spot in Bengal more than 20 m. distant from one of their tributary streams, navigable even in the dry season.

These three great rivers of N. India do not differ more widely in their physical circumstances than in the races of men who inhabit their banks, yet from their position they seem formed to unite nations the most varied in their aspect and speech. The tributaries of the Ganges and Indus come so near to each other at the foot of the mountains that a canal only 2 m. long would unite them, and thus an inland navigation from the Bay of Bengal to the Gulf of Oman might be established.

An immense volume of water is carried through the Indo-Chinese peninsula into the oceans on either side the peninsula of Malacca by the mighty parallel rivers *Irawadi*, *Salwen*, *Me Nam*, and *Me Khong* or *Kambodia*. Having their sources in those elevated regions between the Brahmaputra and the Yang-tsze-Kiang, they flow in meridional direction, and water the great

valleys that extend nearly from N. to S. with perfect uniformity, between chains of mountains no less uniform, which spread out like a fan as they approach the sea. The *Irawadi* has its sources among the S. flanks of the Langtan Mountains, flows S. through the empire of Burma and British Burma, drains an area of 150,000 sq. m. and after a course of 1060 m. through countries which are but little known to Europeans, falls into the Bay of Bengal through the Gulf of Martaban. It is navigable by steamers throughout the British province of Pegu, and beyond Mandalé, the capital of Burma, as far as Bhamo, about 600 m. beyond the sea. From Bhamo there is an overland trade route which for a long time past has been restricted to natives. It was in connexion with the British mission that had for its object the reopening of the great trade route between India and China that the lamented Augustus Raymond Margary was murdered at Manurque on February 22, 1875. From Ava, 446 m. from the sea, the highest point attained by the British forces during the Burmese war, to its delta the Irawadi is a magnificent stream, more than 4 m. broad in some places, but encumbered with numerous islands. It receives the Kjendwen, its largest tributary, on the right bank, and forms in its delta a very extensive system of internal navigation. The Rangun is the only one of its 14 mouths that is always navigable, and in it the commerce of the empire is concentrated. The internal communication is extended by the junction of the two most navigable deltoid branches with the Rivers Salwen and Pegu by natural canals: that joining the former is 200 m. long; the canal uniting the latter is only navigable at high water.

The *Salwen* is thought also to rise in the Langtan Mountains. It flows S. through a deep gorge with a rapid current, often broken by cataracts, one of which puts an abrupt termination to the navigation within 100 m. of the sea. It is 1750 m. long, drains an area of 62,700 sq. m., and falls into the E. side of the Gulf of Martaban. On the E. shore of its estuary lies the harbour of Moulmein.

The *Me Nam* is less known than the Irawadi; it runs through the kingdom of Siam, which it cuts into several islands by many diverging branches, and enters the Gulf of Siam by 3 principal arms, the most easterly of which forms the harbour of Bangkok.

The *Me Khong* or *Kambodia* has the longest course of any river in the peninsula; it rises near the N.W. corner of the Chinese Province of Yunnan. After traversing the elevated plain of Yunnan, where it is navigable, it rushes through the mountain barriers, and is again navigable by boats on reaching a wider valley, for a distance of several hundred miles. About 360 m. from its mouth, it is hemmed in by a hilly range, and forms

numerous cataracts and rapids which destroy its utility as a great artery of communication with the interior.

The ancient capital of Anam is situated on the Kambodia, about 150 m. from the sea; a little to the S. begins the extensive delta of this river, which projects far into the ocean, and is cut in all directions by arms of the river, navigable during the floods; three of its mouths are permanently so for large vessels up to the capital. All rivers of this part of Asia are subject to periodical inundations, which fertilise the plains at the expense of the mountains.

The parallelism of the mountain chains constitutes formidable barriers between the upper basins of the Indo-Chinese rivers, and decided lines of separation between the inhabitants of the intervening valleys; but this inconvenience is in some degree compensated by the natural canals of junction and the extensive water communication towards the mouths of these rivers.

§ 3. **The Chinese River Systems.**—Four great systems of rivers have their origin on the eastern declivity of the great table-land of Central Asia, and, running from W. to E., traverse the Chinese empire:—The *Hong-Kiang,* rising in the province of Yunnan, flowing E. through the plains of Canton, empties itself into the Bay of Canton, having been enlarged by the Se-Kiang. The *Yang-tsze-Kiang* descends in two main streams from the Tang-la Mountains, in the N.E. of Tibet, and is estimated to have a length of 3250 m., a fifth part of which is navigable by large ships. This mighty river, next in size to the Mississippi and the Amazon, is swelled by numerous affluents, chiefly from the N., but also by some from the S. The former, flowing from lofty snow clad mountains, and consequently rushing forth with great violence in the early summer, carries down vast quantities of sand and detritus, so that the main stream is either rapidly obstructed in one part of its bed or deepened in another by new and powerful currents, and so requires very careful navigation. The *Hoang-Ho,* or Yellow River, so called from the quantity of earthy matter it carries down to the sea, is 3000 m. long, and drains an area of 715,000 sq. m. Although its source is near that of the Yang-tsze-Kiang, the two rivers are widely separated by the mountain chains that border the table-land: they approach each other as they proceed on their eastern course, and previous to the year 1851 were not more than 100 m. apart when they entered the Yellow Sea. In that year the river burst through its northern banks near Lan-Yang-hien, in Honan, and by 1853 its lower course was wholly changed, and its waters diverted northward to a new embouchure in the Gulf of Pechili, 260 m. distant from its old mouth. No less than nine such changes are recorded by the Chinese as having taken place during the last 2500 years; the first dating

about 602 B.C., and the ninth the one just described. The positions of the mouths resulting from these changes of the river bed range over an extent of coast line comprised within no less than 5 degrees of latitude. The Yang-tsze-Kiang and the Yellow River, in the lower part of their course, are united by innumerable canals, forming the grandest system of irrigation and of internal navigation in existence.

Strong tides ascend these rivers to the distance of 400 m., and for the time prevent the descent of the fresh water, which forms large interior seas, frequented by thousands of trading vessels; they have irrigated the productive land of Central China, from time immemorial the most highly cultivated and the most densely peopled region of the globe.

Almost all the Chinese rivers of less note—and they are numerous—feed these giant streams, with the exception of the Ta-si or Hong-Kiang and the Pei-Ho or White River, which have their own basins.

The *White River*, rising in the mountains near the Great Wall, becomes navigable a few miles E. of Pekin, unites with the Eu-ho, joins the Great Canal, and, as the tide ascends it for 80 m., it is crowded with trading vessels.

The *Amur*, the sources of which are in Mongolia and the Trans-baikal country, separates in great part of its course Chinese Mandchuria from the Russian province of Amur, is 2400 m. long, including its windings, and has a basin of 800,000 sq. m. Almost all its tributaries come from the Yablonoi Mountains. It is formed by the junction of the Shilka and the Argun, both from the S.W.; and though its course is through an uninhabited country it is celebrated as having been the birthplace and the scene of the exploits of Tshingis Khan. After passing through Lake Dalai Nor, which is 210 m. in circumference, it forms the boundary between China and Russia for 400 m.; it is then joined by the Shilka, where it assumes the Tunguse name of the Amur or *Great River*: the Mandchus call it the Saghalin or Black Water. It receives most of the rivers which come from the mountain slopes of Mandchuria, takes a N. course, and falls into the Pacific opposite to the island of Saghalin, after having traversed 3° of lat. and 33° of long. Its mouth is frozen for 7 months in the year; but in the Island of Saghalin Russia possesses several fine harbours, which will enable her fleets to keep the sea throughout the year, together with extensive beds of coal capable of regularly supplying her steam navy in the North Pacific. The connection of the Baltic and the Caspian Seas is complete, and it now requires only 200 m. of additional canalisation to connect the Caspian and Pacific; when that work is accomplished, the Baltic and Pacific will be united by an unbroken internal navigation of 8000 m.

§ 4. **Siberian Rivers.**—Three great rivers, the *Lena*, the *Yenissei*, and the double system of the *Irtish* and *Ob*, carry off the waters of the Altaï chain, and of the mountains which bound the northern border of the great Asiatic table-land. The *Lena*, the basin of which occupies 782,400 sq. m., rises in mountains W. of Lake Baikal, and runs N.E. through more than half its course to Yakutsk, in Siberia, the coldest town on the face of the earth, receiving in its course the Vitim and the Olekma, its two principal affluents, both from the Yablonoi Mountains. North of Yakutsk, about 63° N. lat., the Lena receives the Aldan, its greatest tributary, which comes from the Yablonoi; it then runs to the Arctic Ocean, between banks of frozen mud, which enclose the bones of those extinct species of elephants and rhinoceroses that at some remote period had found their nourishment in these desert plains.[1] The length of the Lena, including its windings, is 2620 miles.

The *Yenissei*, a much larger river than the Lena, drains about 896,200 sq. m., and has its remotest sources among the S. slopes of the Savansk, and the N. slopes of the Tannu Ola Mountains, W. and N.W. of Lake Kossogol. It crosses the Savansk range in cataracts and rapids, entering the plains of Siberia below the town of Krasnojarsk. Below this many rivers join it, chiefly the Angara from the Lake Baikal; but its greatest tributaries, the S. and N. Tunguska, both large rivers from the Baikalian Mountains, join it lower down, one in lat. 62°, the other in lat. 66° N. It runs thence N. to the Icy Ocean, there forming a large gulf, its length, measured along its bed, being 3020 m.

The *Ob* rises among the defiles of Mount Bielucha in the Altaï Mountains; all the streams of the Lesser Altaï unite to augment its waters and those of its great tributary the Irtish. The rivers which descend from the northern declivity of the mountains go to the Ob, those from the western side to the Irtish. The latter springs from numerous streams on the S.W. declivity of the Little Altaï, and runs westward into the Zaisan Lake, 200 m. in circumference. Issuing thence, it takes a W. course to the plain on the N. of Semipolatinsk, in which it is joined by the Tobol, which crosses the steppe of the Kirghiz Cossacks from the Ural Mountains,

[1] The elephant and rhinoceros of Siberia belong to extinct species the remains of which are widely scattered over the whole of Europe. The Siberian individuals were covered with a thick coating of hair and fur, so different from any of their living congeners, that it suggested to Cuvier the explanation of their being able to exist in so cold a climate, where, from their extraordinary state of preservation, they must evidently have lived, their hairy coats enabling them to brave an excessive climate, whilst they found nourishment in the birch and pine forests of these high latitudes.—See Cuvier, 'Ossemens fossiles,' article 'Eléphants fossiles.'

and then it unites with the Ob; the joint stream proceeds to the Arctic Ocean, into which it falls in 67° N. lat. It is 2700 m. long, and drains an area of 1,294,000 sq. m.

Before the Ob leaves the mountains, at a distance of 1200 m. from the Arctic Ocean, its surface has an elevation of not more than 400 ft., and the Irtish, at the same distance, is only 72 ft. higher; both the currents are consequently sluggish. When the snow melts, they cover the country like seas; and as the inclination of the plains in the middle and lower parts of their course is not sufficient to carry off the water, those immense lakes and marshes are formed which characterise this portion of Siberia.

The bed of the Ob is very deep; and as the water is very deep at its mouth, the largest vessels can ascend the stream as far as the confluence of the Irtish. Its many affluents also might admit ships, did not the climate form an insurmountable obstacle during the greater part of the year. Indeed, all Siberian rivers are frozen annually many months, and even the ocean along the Arctic coasts is rarely disencumbered from ice; therefore these vast rivers never can be important as navigable streams. They abound in fish and water fowl, for which the Siberian peasant braves the extremest severity of the climate.

Local circumstances have nowhere produced a greater difference in the human race than in the basins of the great rivers N. and S. of the table-land of Eastern Asia. The Indian, favoured by the finest climate, and a soil which produces the luxuries of life, intersected with rivers navigable at all seasons, and affording easy communication with the surrounding nations, attained early a high degree of civilisation, which has since been lost; while the Siberian and Samoyede, doomed to contend with the rigours of the polar blasts in order to maintain mere existence, have never risen beyond the lowest grade of humanity; but custom softens the rigour of this stern life, so that even here a share of happiness is enjoyed.

CHAPTER XXI.

AMERICAN AND AUSTRALIAN RIVERS.

§ 1. **River Systems of North America.**—North America is divided into four distinct water systems by the Rocky Mountains, the Alleghanies, and the table-land which contains the great lakes, and separates the rivers that flow into the Arctic Ocean from those which run into the Gulf of Mexico. This table-land, which is a level nowhere more than 1200 or 1500 ft. above the surface of the

sea, is the watershed of the Mississippi, the Mackenzie, the St. Lawrence, and of the rivers that flow into Hudson Bay. The *St. Lawrence* rises under the name of St. Louis in Kaginoshensikag Lake, to the N.W. of Lake Superior; after connecting the Lakes Superior, Huron, Erie, and Ontario, it issues from the last as the St. Lawrence, and expanding in its N.E. course into the Lakes of St. Francis, St. Louis, and St. Peter, it runs N.E. and after a course of 2080 m. enters the Atlantic with an embouchure 120 m. wide. Its tributaries are larger than European rivers, and several of those that fall into the Ottawa are greater than the Thames. The granite capes and headlands on the gulf are of striking grandeur; the boldest and loftiest part of this granite wall is cleft by an enormous fissure, through which the Saguenay flows. The waters of this great tributary run beneath a perpendicular bank, the river being in some places a thousand feet deep.[1] The St. Lawrence has a basin of 1,100,000 sq. m., of which 93,700 are covered with water, exclusive of the many lesser lakes with which it is in communication.

N. of the watershed there is a labyrinth of lakes and rivers, almost all of which are connected with one another. But the principal streams of these Arctic lands are—the *Great Fish River*, now called the *Black River*, which flows N.E. in a continued series of dangerous and all but impassable rapids to the Arctic Ocean through Ross Strait and M'Clintock Channel; the *Coppermine River*, of much the same character, which, after traversing many lakes, enters the Icy Sea at Coronation Gulf; the *Mackenzie River*, a stream of greater magnitude, formed by the confluence of the Peace River from the Babino Mountains, and the Athabasca from Mount Brown, which, after flowing N. over more than 16 degrees of latitude, enters the Frozen Ocean by many mouths in the Esquimaux country beyond the Arctic Circle, in lat. 68° 50′ N.; and the *Colville*, a river of Alaska, which enters the sea in 151° W. long., at Harrison's Bay. All these rivers are frozen more than half the year, and the Mackenzie, in consequence of its length and direction from S. to N., is subject to floods like the Siberian rivers, because its lower course remains frozen for several hundred miles long after the upper part has thawed, and the water, finding no outlet, flows over the ice and inundates the plains. The *Yukon*, or *Kwich-pak*, is a magnificent river, 1500 m. long, draining 250,000 sq. m. of country to the W. of the basin of the Mackenzie. Near long. 147° W. it is joined by the Porcupine River on its right bank. In long. 158° W., the river bends southward, a course which it pursues for over 200 m. It then turns W., and falls into

[1] 'Quarterly Review,' Jan 1861.

Norton Sound by numerous mouths, of which the most northerly, the Aphoon, is navigable, though all are blocked up by ice till the beginning of June and freeze again in October. The Upper Yukon, which has been explored for 600 m. above the junction of the Porcupine, runs through mountain gorges; and at some distance below the confluence of the Porcupine the heights on the banks are known as the 'Ramparts,' and tower grandly above the river. Many islands are formed in its course, and it is in several places obstructed by rapids; but there are none which would prevent the navigation of the river, during the time it is open, by such steamers as are used on American rivers. The banks of the Yukon are in many places well wooded with pine, poplar, willow, and birch; and the river abounds in salmon.

Although the Arctic coast is so stern, a magnificent country to the S. has been for many years in possession of the British empire, which may in future be a rich and flourishing colony, but which has hitherto only supplied the London market with fur. It contains two rivers now become of great importance—the *Saskatchewan* and the *Red River*. The S. and N. branches of the former have their origin in the E. slopes of the Felsen section of the Rocky Mountains. The first part of the course of the S. branch is through a country that is partly arid, but the N. branch flows through prairies of great fertility. After being increased by large tributaries, the two branches unite and ultimately fall into Lake Winnipeg. Leaving the lake at its N.E. corner, it flows N., then N.E., as the *Nelson River*, and, after a course of 1930 m., falls into Hudson Bay N.W. of Cape Tatnam. The *Red River* rises in Elbow Lake, in Minnesota, and, after cutting a winding course for 100 m., falls into the southern part of Lake Winnipeg.

S. of the table-land the valley of the *Mississippi* extends for 1000 m., and this greatest of North American rivers has its origin in the small Lake of Itaska, on the table-land at no greater height than 1680 ft. above the sea. This river flows from N. to S. through more degrees of latitude than any other, and receives so many tributaries of the higher orders that it would be difficult even to name them. Among those that swell its volume from the Rocky Mountains, the *Missouri*, the *Arkansas*, and the *Red River* are the largest, each being in itself a mighty stream, receiving tributaries without number. Before their junction the *Missouri* is a river much superior to the Mississippi both in length and volume, and has many affluents larger than the Rhine. It is formed by the union, at Point Three Forks, in lat. 46° N. and long. 111° 30′ W., of the Rivers Jefferson, Madison, and Gallatin, and runs partly in a longitudinal valley of the Rocky Mountains, and partly at their foot, and drains the whole of the country on the right bank of the

Mississippi between 49° and 40° N. lat. It descends in cataracts through the mountain regions, and in the plains it sometimes passes through large prairies and sometimes through dense forests, traversing in all 3000 m., in a very tortuous and generally S.E. direction, till it joins the Mississippi near the town of St. Louis. Lower down, the Mississippi is joined by the *Arkansas*, 2170 m. long, with many tributaries, and then by the *Red River*, the former from the Rocky Mountains; the latter, which rises in the Staked Plain of Texas, is fed by rivers from the Sierra del Sacramento, and enters the main stream in lat. 31° N. and long. 91° 40′ W. At the head of its delta, which is larger than that of the Nile, the Mississippi sends off a large branch called the Atchafalaya to the S., and then turning to the E. it discharges itself by 5 mouths at the extremity of a long tongue of land which stretches 50 m. into the Gulf of Mexico. The shore is lined with shallow salt lagoons; the greater part of the delta is covered with water and unhealthy marshes, the abode of the crocodile, and is during the floods a muddy sea. This river is navigable for 2240 m. Its valley is of variable width, but at its greatest breadth, at the junction of the White River, it is 80 m. The tributaries from the Rocky Mountains, though much longer, run through countries of less promise than those which are traversed by the Ohio and the other rivers that flow into the Mississippi from the E., which offer advantages unrivalled even in this wonderful country. The *Ohio* is formed by the union of the Rivers Alleghany and Monongahela, the latter from the Laurel ridge of the Alleghany chain in Virginia; the former from the vicinity of Lake Erie; and the two unite at Pittsburg, from whence the river winds for 948 m. through some of the finest States of the Union, to its junction with the Mississippi, having received many accessories, 6 of which are navigable streams. There are some obstacles to navigation in the Ohio, but they have been avoided by canals. Other canals join both the Mississippi and its branches with Lake Erie, so that there is an internal water communication between the St. Lawrence and the Gulf of Mexico. The whole length of the Mississippi is 3160 m.; but, if the Missouri be considered the main stream, it is 4350, and the joint stream drains an area of 1,235,000 sq. m. The breadth of the river nowhere corresponds with its length. At the confluence of the Missouri each river is half a mile wide, and after the junction of the Ohio it is not more. A steamer may ascend the Mississippi for 2000 m. from Balize without any perceptible difference in its breadth. The depth is 168 ft. where it enters the Gulf of Mexico at New Orleans: the fall of the river at Cape Girardeau is 4 inches in a mile. This river is a rapid, desolating torrent loaded with mud: its violent floods, from the melting of the snow in the high

latitudes, sweep away whole forests, by which the navigation is rendered very dangerous at times, and the trees, being matted together in masses many yards thick, are carried down by the spring floods, and deposited over the delta and Gulf of Mexico for hundreds of square miles.

North America can boast of two other great water systems: one from the eastern declivity of the Alleghanies, which flows into the Atlantic; and another from the western side of the Rocky Mountains, which runs into the Pacific.

All the streams that flow eastward through the United States to the Atlantic are short, and of comparatively small volume, but of the highest utility, because many of them end in gulfs or estuaries, and the whole are so united by canals that there are few places which are inaccessible by water—one of the greatest advantages a country can possess. There are at least 24 great canals in the United States, the length of which is 3101 m. This is an important addition to the already great extent of inland navigation furnished by the rivers.

Many of the streams which fall into the Atlantic rise in the western ridges of the Alleghany chain, and traverse its longitudinal valleys before leaving the mountains to cross the Atlantic slope, which terminates in a precipitous ledge for 300 m. parallel to the range. By falling over this rocky barrier in long rapids and picturesque cascades, they afford an enormous and extensive water power; and as the rivers are navigable from the Atlantic quite across the maritime plains, these two circumstances have determined the location of most of the principal cities of the United States at the foot of this rocky ledge, which, though not more than 300 ft. high, has had a greater influence on the political and commercial interests of the Union than the highest chains of mountains have had in other countries. The *Hudson* in the N. is navigable to Albany; the *Delaware*, and *Susquehanna*, ending in bays, are important rivers; and the *Potomac*, which falls into Chesapeake Bay, passes by Washington, the capital of the United States, to which the largest ships can ascend.

The watershed of the Rocky Mountains lies at a greater distance from the Pacific than that of the Alleghanies from the Atlantic: consequently the rivers are longer, but they are few, and were little known till they were discovered to be so rich in gold. The *Fraser*, and its tributaries, the Anderson and Thompson, in British Columbia, are highly auriferous, and there is every reason to believe that the Nasse is equally so. It is more to the N., and flows between immense mountains, whose summits are covered with perpetual snow, and through a country which, like the whole of the N.W. coast of British Columbia, is one long continuous formation of slate with

frequent veins of crystallised quartz, and at intervals indications of ancient volcanic action; the miners believe the whole district to be highly auriferous. About 110 m. from Fort Simpson the Nasse makes a rectangular turn, falling at the rate of 10 or 12 ft. in a mile: the water rushes furiously, forming below the angle a whirlpool 300 ft. in circumference, upon the outer edge of which the waters boil up from beneath as from a caldron, raising the level of the current several feet, and then bursting with a fury that carries everything before it; and about 3 m. lower down the river forms a regular cascade, and falls into the Pacific in 54° 40′ N.

Only patches of land are fit for cultivation, but 80 m. from the mouth of the river the Indians plant great crops of potatoes, so that a mining establishment might be supplied with food.

The peculiar nature of that part of the watershed of the Rocky Mountains that belongs to British Columbia was first brought into notice by Mr. John Ball. 'Except in the Carpathian chain, we have nowhere in the Old World anything exactly like it. The rivers seem to pass across the axis of greatest elevation. The two main branches of the Saskatchewan River pass to the westward of the highest mountains in the chain, Mount Murchison and Mount Hooker; and on the western side of the chain we have this extraordinary fact—two rivers flowing parallel to each other, a few miles apart, for a long distance, the Columbia and the Kutanie, one running to the N.W. and the other to the S.E. It is one of the most singular facts in physical geography.' The largest of the rivers W. of the Rocky Mountains are the *Oregon* or *Columbia*, and the *Rio Colorado*. The former has its sources among the Kananaski Peaks on the W. side of the Rocky Mountains; and after an exceedingly tortuous course, in which it receives many tributaries, it falls into the Pacific between Capes Adam and Disappointment. The *Colorado* is formed by the union of the Green River from Fremont's Peak and the Grand River, which has its remotest sources in the Parks, and falls into the Gulf of California. It receives numerous tributaries, of which the San Juan, the Little Colorado, and the Gila are the chief. The basin of the Colorado has an area of 267,000 sq. m., and is bounded on the E. by the Sierra Madre of New Mexico, and on the N.W. by the Wahsatch Mountains. It is of a triangular shape, and consists of successive table-lands of from 4000 to 7000 or even 8000 ft. in elevation, having abrupt edges and barren surfaces. Through these table-lands the Colorado and its tributaries have worn deep and remarkable gorges, called cañons, the largest of which is the great cañon of the Colorado, which is 300 m. long. The sides of this gorge rise from 1000 ft. to nearly a mile in perpendicular height. The parts of the table-land which

are traversed by these cañons are barren, as all the water flows away in the deep valleys, and tributary streams come to the chief river through tributary cañons.[1]

The Wahsatch Mountains, which are 60 m. broad, separate the Colorado Basin from what is called the Great Basin, which lies W. and N.W. of the range, and has an area of 280,000 sq. m. This is watered by numerous small streams which flow into salt lakes. The *Humboldt* is one of the largest of the rivers found in the Great Basin; and the Great Salt Lake, near which is the Mormon settlement, is one of the chief lakes. The *Sacramento*, with its tributaries, a Californian stream, lies W. of the Sierra Nevada, and flows through an extensive and rich auriferous country in its course to the Bay of San Francisco on the Pacific.

On the table-land of Mexico there is a basin of continental streams which, rising from springs on the eastern side of the Sierra Madre, and fed by the periodical rains, flow northward and terminate in lakes that part with their superfluous water by evaporation. Of these the *Rio Grande* which, after a course of 300 m., falls into the Parras, is the greatest.

The largest river in the isthmus of Mexico is the *Rio S. Iago*, which rises on the table-land of Toluca, forms numerous cascades, and falls into the Pacific after a course of 400 m. The river of *Goatzacoalcos*, which traverses the isthmus nearly from sea to sea, emptying itself into the Gulf of Mexico, has by some been considered as the best point for a sea canal between the two oceans.

§ 2. **River Systems of Central America.**—There are many streams in Central America, and above 10 rivers that are navigable for some miles; 6 of these fall into the Gulf of Mexico and Caribbean Sea, and 4 into the Pacific. Of these are the *Rio Montagua*, which, rising in the mountains near Guatemala, flows into the Gulf of Honduras; and the *Blewfields River*, the greater part of the course of which is in the Mosquito territory.

In the southern part of the State of Nicaragua is situated the river of *San Juan*, which drains the lakes of Nicaragua and Managuya, and by which it is supposed a water communication could be easily effected between the Atlantic and the Pacific.

§ 3. **The River Systems of South America.**—The Andes,

---

[1] The word *cañon* is used to express the clefts through which many of the rivers of the west of America flow for long distances. Sometimes the term is applied to a mountain-gorge, as the cañon of the Fraser in British Columbia, and sometimes to such a gorge as that described as occurring in the course of the Colorado. In every case, cañons are the result of the eroding action of the river, and no rocks, however hard, are found capable of resisting it.

the extensive watershed of South America, are so close to the sea that there are no rivers of considerable size which empty themselves into the Pacific: even some of the streams that rise in the western cordilleras find their way to the eastern plains.

The *Magdalena*, at the N. end of the Andes, though a secondary river in America, is 900 m. long. It rises in the central chain, at the divergence of the cordilleras of Suma Paz and Quindiu, and enters the Caribbean Sea by various channels: it is navigable as far as Honda. The Cauca, its only feeder on the W., comes from Popayan, and is nearly as large as its primary, to which it runs parallel the greater part of its course. Many streams join the Magdalena on the right, as the stream which waters the elevated plain of Bogota, and forms the cataract of Tequendama, one of the most beautiful and wildest scenes in the Andes. The latter river rushes through a chasm 30 ft. wide, which appears to have been formed by an earthquake, and at a double bound descends 530 ft. into a dark gloomy pool, illuminated only at noon by a few feeble rays. A dense cloud of vapour rising from it is visible at the distance of 15 m. At the top the vegetation is that of a temperate climate, while palms grow at the bottom.

The River *Atrato*, parallel to the Cauca and Magdalena, but less considerable, empties itself into the Gulf of Darien. The Rivers *Patia*, *San Suan*, *Las Esmeraldas*, and *Guayaquil*, all rise on the W. declivity of the Andes and flow into the Pacific. With these exceptions all the water from the inexhaustible sources of the Andes N. of Chile is poured into the Orinoco, the River Amazon, and the Rio de la Plata, which convey it across the continent to the Atlantic. In the far S., indeed, there are the *Colorado*, and *Rio Negro*, but they are insignificant when compared with the three giant floods above named.

The basins of these three rivers are separated in their lower parts by the mountains and highlands of Guiana and Brazil; but the upper parts of the basins of all three form an extensive level, and are only divided from one another by imperceptible elevations in the plains, barely sufficient to form the watersheds between the tributaries of these majestic rivers. This peculiar structure is the cause of the natural canal of the Cassiquiare, which joins the Upper Orinoco with the Rio Negro, a principal affluent of the Amazon. Ages hence, when the wilds shall be inhabited by civilised man, the tributaries of these three great rivers, many of which are navigable to the foot of the Andes, will, by means of canals, form a water system infinitely superior to any that now exists.

The *Orinoco* rises in the Sierra Parima, 200 m. E. of the elevated Peak of Duida, and maintains a westerly course to San Fernando de Atabapo, where it receives the Atabapo and Guaviare;

here ends the Upper Orinoco. The river then forces a passage through the Sierra Parima, and runs due N. for three degrees of lat., between banks almost inaccessible; its bed is traversed by dykes, and filled with boulders of granite and islands clothed with a great variety of magnificent palm trees. Large portions of the river are here engulfed in crevices, forming subterranean cascades; in this portion are the celebrated falls of the Atures and Apures, 36 m. apart, which are heard at the distance of many miles. At the end of this tumultuous part of its course it is joined by the Meta, and farther N. by the Apure, two very large rivers, which drain the whole eastern side of the Andes in an extent of 10 degrees of lat.; it then runs eastward to its mouth, where it forms an extensive delta, and enters the Atlantic by many channels. As the Upper Orinoco runs W., and the Lower Orinoco E., it makes a complete circuit round the Parima mountain system, so that its mouth is only two degrees distant from the meridian of its sources.

The *Cassiquiare* leaves the Orinoco near the S. base of the Peak of Duida, and joins the Rio Negro, a chief tributary of the Amazon, at the distance of 180 m. It is navigable for 1000 m. at all times of the year; a fleet might ascend it from the Dragon's Mouth to within 45 m. of Santa Fé de Bogota. It receives many navigable rivers, of which the Guaviare, the Atures, and the Meta are each larger than the Danube. The *Meta* may be ascended to the foot of the Andes; its mean depth is 36 ft., and in many places 80 or 90 ft. It rises at so great an elevation in the Andes that Humboldt says the vegetable productions at its source differ as much from those at its confluence with the Orinoco, though in the same latitude, as the vegetation of France does from that of Senegal. The larger feeders of the Orinoco come from the Andes, though many descend to it from both sides of the Parima, in consequence of its long circuit among these low mountains. The basin of the Orinoco has an area of 320,000 sq. m., of which the upper part is one impenetrable forest; the lower consists of those extensive plains called Llanos.

The floods of the Orinoco, like those of all rivers entirely within the torrid zone, are very regular, and attain their height nearly at the same time with those of the Ganges, the Niger, and the Gambia. They commence rising about March 25, arrive at their greatest height, and begin to decrease, about August 25. The inundations are very great, owing to the quantity of rain that falls in the regions close to the Andes, which is said to exceed 1000 inches in a year.

Below the confluence of the Apure the river is 3 m. broad, but during the floods it is three times as much. By the confluence of

four of its greatest tributaries at the point at which it bends to the E., a low inland delta is formed, in consequence of which 3600 sq. m. of the plain are under water during the inundations.

Upper Peru is the cradle of the *Amazon* (*Marañon*, *Orellana*, or *Solimoens*), the greatest of rivers, which drains the chain of the Andes from the equator to 20° S. lat. Its head streams, the Tunguragua and the Yucayali, take their rise at a great elevation among the Peruvian Andes, the one in Lake Lauricocha and the other on the W. flanks of the Andes of Vilcañota, a little to the N.W. of Lake Titicaca; it runs in a deep longitudinal valley from S. to N., till it bursts through the eastern ridge at the Pongo de Manseriche, near the town of San Borja, from whence it follows a uniform E. course of nearly 4000 m., including its windings, till it reaches the Atlantic. The estimated area of its basin is 2,500,000 sq. m., or more than a third part of South America. In some places it has a great depth: it is navigable by its tributary the Yucayali as far as 3600 m. from its mouth, where it is 96 m. wide.

The number, length, and volume of the tributaries of this river are in proportion to its magnitude; even the affluents of its affluents are noble streams. More than 20 superb rivers, 1000 m. and upwards in length, pour their waters into the Amazon, and streams of less importance are numberless. The chief of these are the *Huallaga*, which has its origin near the mining district of Pasco, and, after a N. course of 500 m., joins the Marañon in the plains; it is almost a mile broad above its junction. The Spanish Governor of Peru sent Pedro de Orsua down this river in the year 1560 to search for the Lake of Parima and the city of El Dorado. The *Yucayali*, one of the head streams of the Amazon, is considered by some eminent geographers to be the trunk stream of this colossal river system. In a course of 1200 m. it is fed by tributaries from a wide extent of country, and at its junction with the main stream, near the mission of San Joaquim de Omaguas, a line of 50 fathoms does not reach the bottom, and in breadth it is more like a sea than a river. By this stream and its western tributary, the Pachitea, there is access to S. Peru within 200 m. of Lima, and there is communication between the Amazon and the most distant regions around by other navigable feeders. It is only through the enterprise of a private English gentleman, Mr. W. Chandless, that anything has been made known of the rivers that empty themselves into the Amazon on its southern bank, between the Yucayali and the Madeira; one of the principal is the *Purus*, a noble river, 1880 m. in length; it rises in the forest plains E. of the Yucayali, at an elevation of about 1100 ft. only. It flows, throughout the whole of its long winding course, through a plain of extreme fertility

covered with an uninterrupted forest, and is navigable by steamers for about 1000 m. The *Madeira*, which is the greatest affluent of the Amazon, and nearly 2000 m. in length, rises near the sources of the Paraguay, the principal tributary of the Rio de la Plata. The Amazon is not less extensively connected on the N. The high lands of Colombia are accessible by the *Putumayo*, the *Japurá*, and other great navigable rivers; the *Rio Negro*, several miles broad a little way above its junction with the Amazon, connects it with the Orinoco by the Cassiquiare; and lastly, the sources of the Rio Branco approach very near to those of the Essequibo, an independent river of Demerara.

The main stream, from its mouth nearly throughout its length, is full of islands, and most of its tributaries have deltas at their junction with it. The annual floods of the Amazon are less regular than those of the Orinoco, and, as the two rivers are on opposite sides of the equator, they occur at different seasons. The Amazon begins to rise in November, is at its greatest height in the beginning of June, and its least in September and October. The Amazon separates into two branches at its mouth, one of which joins, by several long and very narrow channels, the Parà S. of the island of Marajo; the other enters the ocean to the N. of it.

The water of some of the rivers in equatorial America is whitish; in others it is of a deep coffee colour, or dark green when seen in the shade, but perfectly transparent, and, when ruffled by a breeze, of a vivid green, like some of the Swiss lakes. In Scotland the brown waters derive their colour from peat mosses; but it is not so in America, since they occur as often in forests as in savannahs. Sir Robert Schomburgk thinks they are coloured by ores of iron imbedded in the granite over which they flow; however, the colouring matter has not been chemically ascertained. The Orinoco and the Cassiquiare are milky; the Rio Negro, as its name implies, is black, yet the water does not stain the rocks, which in some places are of a dazzling white.

The *Rio de la Plata* forms the third great river system of South America. The *Rio Grande*, its principal stream, rises in the mountains of Minas Geraes, in Brazil, and runs 500 m. on the table-land from E. to S.W. before it takes the name of Paranà. For more than 100 m. it is a continued series of cataracts and rapids, the greatest of which, the Salto Grande, is in about lat. 24° 5′. Above the fall the river is 3 m. broad, when all at once it is contracted in a rocky pass only 60 yards wide, through which it rushes over a ledge with thundering noise, heard at the distance of many miles. The *Paranà* receives three large rivers on the right—the Paraguay, the Pilcomayo, and the Vermejo; all trend to the S.E., and unite at different distances before entering their primary at Corrientes.

The *Paraguay*, 1200 m. long, is the largest of the three; in its upper part it is singularly picturesque, adorned with palms and other tropical vegetation; its islands are covered with orange groves. It springs from a chain of seven lakes, on the S. slopes of the Sierra Pary, in Brazil, and may be ascended by vessels of considerable burthen through 19° of latitude. The *Pilcomayo* and *Vermejo* both come from Bolivia, and both traverse the Gran Chaco, inhabited by savage tribes; the former joining the Paraguay opposite Asuncion, and the latter near Pillar. The *Salado*, which runs into the Paranà, might be rendered navigable as far as the province of Salta; it would open an extensive country to commerce. At Rosario the Paranà turns eastward to form the Plata proper, and before entering the Atlantic, is augmented by the Uruguay from the N.

The *Rio de la Plata* is 2700 m. long, and for 200 m. from its mouth, up to Buenos Ayres, it is more like a great sea estuary than a river, being never less than 170 m. broad. Were it not for the freshness of its water, it might be mistaken for the ocean: it is, however, shallow and loaded with mud, which discolours the Atlantic for 200 m. from its mouth.

The Paraguay is subject to great floods, which carry destruction and desolation with them. The atmosphere at times is poisoned by the putrid carcases of drowned animals brought down by it. The ordinary annual inundations of the Paranà, the principal or upper branch of the Plata, cover 36,000 sq. m.

The *Colorado*, which runs in a long shallow stream through the Pampas of Buenos Ayres, is formed of two principal branches, one from the W. and the other from the N., which unite at a great distance from the Atlantic, into which the river flows.

The *Rio Negro* rises at a great elevation on the western declivity of the Andes, and separates the Pampas from Patagonia. In its long course through arid deserts to the Atlantic it does not receive a single tributary, but it forms a communication between that ocean and Chile, as it reaches a pass in the Andes that is free from snow. There is some vegetation in its immediate neighbourhood; it has a bar at its mouth, and is navigable only for 4 m. above Carmen; it has periodical floods twice in the year, one produced by the rains, the other by the melting of the snow in the Andes.

There are various rivers in South America, unconnected with those described, which in any other country would be esteemed of a high order. Of many which descend from the high country of Guiana, the *Essequibo* is the largest; its general width is a mile and a quarter; its water, though black, is clear; and on its banks, and those of all its tributaries, the forest reigns in impenetrable thickness. It rises in the Sierra Acaray, which separates its basin

from that of the Amazon, and, after a northerly course, falls into the Atlantic near 7° N. lat. by an outlet 14 m. broad, separated by three low islands into four branches. Sir Robert Schomburgk, whose journeys have made us acquainted with a country of which so little was known, has shown that, by cutting a canal three miles long between the Madeira and the Guapore, an affluent of the Mamore, an inland navigation might be opened from Demerara to Buenos Ayres, over an extent of 42° of latitude, with the exception of a portage of only 800 yards in the rainy season between Lake Amucu and the Quatata, a branch of the Rupununi, which flows into the Essequibo. 'If,' says the distinguished traveller already mentioned, 'British Guiana did not possess the fertility which is such a distinguishing feature, this water communication alone would render it of vast importance; but, blessed as it is with abundant fruitfulness, this extensive inland navigation heightens its value as a British colony; and, if emigration sufficient to make its resources available were properly directed thither, the port of Demerara would rival any in the vast continent of South America.' It is certainly remarkable that the tide of emigration has never set towards a country of such promise, abounding in valuable natural productions, and so much nearer to Great Britain than her colonies in the Pacific.

The *Parà* and *São Francisco* are among the chief rivers of Brazil; and both rise on the table-land; the Parà is formed by the Tocantins and numerous other rivers flowing from the S. The Tocantins, descending from the highlands in rapids in its northerly course, after running 1500 m., is joined by the southern branch of the Amazon before entering the Atlantic as the Parà, S. of the Island of Marajo. The *São Francisco* is 1814 m. long; it rises in the Serra da Canastra, the central platform of the province of Minas Geraes, and, after running northward between mountain ranges parallel to the coast, it breaks through them, and reaches the ocean about 10° 20′ S. lat. The principal stream bursts from the gap of a perpendicular rock, more than 1000 ft. high. Its early course, when it is little more than a mountain torrent, is eastward. It then flows N., with the Espinhaço or Mantiqueira range on the E., and the Matta da Corda as the western wall of its valley; at the end of its course its direction is south easterly. It receives several tributaries, the chief of which is the Rio das Velhas, in whose valley are the principal gold mines of Minas Geraes. Its course is in several places obstructed by rapids, and about 180 m. above its mouth occur the Great Rapids and Waterfall of Paulo Affonso, which have been visited and described by Captain Burton. Above and below the fall about 75 m. are unnavigable. Above the fall occur the rapids of the Itaparíca, where the waters,

'spuming and whirling from the prison walls of iron, rush roaring into one another's arms; all is dark and lurid as a river of the "Inferno."' The Paulo Affonso is very grand. At the principal cataract, the gorge is 260 ft. deep, and in the narrowest part choked to a minimum breadth of 51 ft. The height of the Great Cataract is 192 ft.; but the Paulo Affonso is really a succession of rapids and caldrons, ending in a mighty fall, whose 'thunder' is heard at some miles distant. The fall plunges into a ravine, whose black sides, from 570 to 250 ft. high, wall in the stream for 48 m. below the cataract. The river is navigable for steamers from Pirhanhas to its mouth below the city of Penedo. The river valley is very fertile; 'here the sugar cane and the pine apple may be seen by a spectator, standing in the barley field and the potato patch.' Cattle, sheep, and goats are easily reared in the uplands. Silk and cotton are produced. Of minerals are found diamonds, agates, gold, iron, platinum, lead, mercury, copper, antimony, &c., and many building stones. Salt, saltpetre, sulphur, and alum are found in large deposits. All the vegetables of temperate and subtropical regions will grow in the valley; and timber and dye woods are abundant. The country is very fit to receive emigrants. As in the Appalachian chain, so here, many rivers cross the edge of the table-land to the level maritime plains of the Atlantic.

The historical renown and the high civilisation of Asia and Europe, their great wealth and population, may be attributed in a very great degree to the facility of transport afforded by their admirable river systems, and still more to the genius of the people who knew how to avail themselves of them; the same may be said of the inhabitants of the United States of America—while the Indians of both the American continents, who have possessed these countries for ages, never took advantage of the noble streams with which Providence had enriched and embellished their country, it being left to the Anglo Saxon race to make them one of the great sources of unparalleled prosperity.

§ 4. **Rivers of Australia.**—After America, the land of the river and the flood, Australia appears in more than its usual aridity. The absence of large perennial rivers is one of the greatest impediments to the improvement of this continent.

The streams from the mountains on the eastern side of the continent are mere torrents, and would have short courses did they not run in longitudinal valleys; the *Hawkesbury*, *Clarence*, *Brisbane*, *Fitzroy*, and *Burdekin* are the largest of the rivers which empty themselves on the E. coast.

The most important river of the continent flows to the southern coast. It is formed, in the first place, of the Murrumbigee, which

rises among the S.E. flanks of Mount Murray and, running N. and W., meets the Kalare or Lachlan, flowing from the E. After their junction they run into the *Murray*, a much larger stream, though only 350 ft. broad, and not more than 20 ft. deep. Lower down the *Darling* enters the Murray, and is the largest of its affluents, draining the W. declivity of the mountains of South Wales, between 26° and 35° S. lat.; as the Lachlan, the Murrumbigee, and the Murray do the S. portion of the same high lands, and the N. declivity of the auriferous region of the colony of Victoria. The breakers at the mouth of the Murray are dangerous, but may be passed in fine weather in a good steamer.

The Murray has been navigated for 2650 m.; a considerable distance farther will probably be reached through some of its tributaries, and several of the rivers may be ascended to a greater distance than was supposed to be possible.

The *Macquarrie* is one of the principal tributaries of the Darling; after running 300 m. N.W. it passes through marshes, and afterwards enters that river. In its upper course the Darling is called the Barwan. In addition to the Castlereagh, the Macquarrie, and the Bogan, which are its chief tributaries from the S., it receives from the N. the Ballone and the Warrego.

The W. slope of the coast range N. of lat. 25° S. is drained by the *Thomson* with its tributary, the Barcoo or Victoria. This river has a course of about 600 m. in length, and finds its way to Cooper's Creek, towards which certain other streams or creeks also flow, thus forming an internal continental basin. The *Paru* River, between the Warrego and the Thomson, loses itself in the sand. None of the rivers which drain the northern part of the western slope of the eastern range, nor the southern slope of the heights which encircle the Gulf of Carpentaria, ever reach the sea.

The *Blackwood*, *Swan*, *Murchison*, *Gascoyne*, *Ashburton*, *Fortescue*, and *De Grey* drain the western side of the continent; and along the banks of some of these are fertile grassy plains. The Victoria, opening into Queen's Channel, in N.W. Australia, was explored by Mr. A. C. Gregory, in 1856.

The streams opening into the Gulf of Carpentaria are inconsiderable in length, as they descend only from the semicircular range of hills that enclose this extensive tropical sea; the *Roper*, *Albert*, *Flinders*, and *Mitchell* are the largest of these rivers. The want of water makes it difficult to explore the interior of this continent. It appears that in certain groups of years there are great falls of rain over large portions of the plains, which become saturated with water: lakes are formed and temporary streams; what is not evaporated sinks into the earth, and may supply artesian

wells. Stuart found, in his journeys N. from Adelaide, that he could frequently obtain water by digging. Then years succeed in which no rain falls. Wherever there is moisture there is fertility, so in the central arid part of the interior there are productive oases alternating with unproductive tracts, and the most recent explorations have shown that the interior of Australia possesses much more water than the early travellers reported.

CHAPTER XXII.

LAKES.

§ 1. **General description of Lakes.**—The hollows formed on the surface of the earth by the ground sinking or rising, by earthquakes, craters of extinct volcanoes, the intersection of strata, and by ancient glaciers, are generally filled with water, and constitute systems of lakes, some salt and some fresh. Many of the former may be remnants of an ancient ocean, left in the depressions of its bed as the waters retired when the continents were raised above its surface.

Many lakes are fed by springs rising at the bottom, and they are occasionally the sources of the largest rivers. Some have neither tributaries nor outlets; the greater number have both. The quantity of water in lakes varies with the seasons everywhere, especially from the melting snow on mountain chains, and in high latitudes, and from periodical rains between the tropics. Small lakes occur in mountain passes, formed by water which runs into them from the surrounding peaks; they are frequently, as in the Alps, very transparent, of a bright green or azure hue. Large lakes are common on table-lands, and in the valleys of mountainous countries, but the largest are on extensive plains. The basin of a lake comprehends all the land drained by it; consequently it is bounded by an imaginary line passing through the sources of all the the waters that fall into it.

§ 2. **European Lakes.**—There are more lakes in high than low latitudes, because evaporation is much greater in low latitudes than in high, and in this respect there is a great analogy between the northern plains of the two principal continents. Sheets of water of great beauty occur in the mountain valleys of the British Islands, of Norway and Sweden, countries similar in geological structure; and besides these there are two regions in the Old World in which

lakes particularly abound. One begins on the low coast of Holland, encircles the southern and eastern sides of the Baltic, often passing close to its shores, along the Gulf of Bothnia, and from thence through the Siberian plains to Behring Strait. The lakes which cover so much of Finland and the great lakes of Ladoga and Onega lie in a parallel direction; they occupy transverse rents which had taken place across the palæozoic strata, while rising in a direction from S.W. to N.E., between the Gulf of Finland and the White Sea; that elevation was, perhaps, the cause of the cavities now occupied by these two seas. *Ladoga* is the largest lake in this zone, having a surface of 7151 sq. m. It receives tributary streams, and sends off its superfluous water by rivers; and *Onega* does the same; but the multitude of small steppe lakes among the Ural Mountains and in the basin of the River Ob neither receive nor emit rivers, being for the most part mere ponds, though of great size, some of fresh and some of salt water, lying close together—a circumstance which has not been accounted for: those on the low Siberian plains have the same character.

In the Pyrenees lakes are most frequent on the French side; many are at such altitudes as to be perpetually frozen; one on Mont Perdu, 8393 ft. above the sea, has the appearance of an ancient volcanic crater. There is scarcely a valley in the Alpine range and its offsets that has not a sheet of water filling cavities formed during the elevation of the ridges by subsidence of the soil and afterwards scooped out by glaciers: *Lake Trub*, 7200 ft. above the level of the sea, is the most elevated. Lakes are more numerous on the N. than on the S. of the Alps—the German valleys are full of them. In Bohemia, Gallicia, and Moravia there are no less than 30,000 sheets of water, besides numerous others in Austria proper.

Of the principal lakes on the N. side of the Alps, the *Lake of Geneva*, or *Lake Leman*, is the largest and most beautiful, from its situation, the pure azure of the waters, and the sublime mountain scenery that surrounds it. Its surface, of about 221 sq. m., is 1230 ft. above the sea, and near Meillerie it is 1012 ft. deep. The *Lake of Lucerne* is 1433 ft. above the sea, and the *Lake of Brienz* 1850 ft. The Italian lakes are at a lower level; the *Lago Maggiore* has only 697 ft. of altitude; the *Lake of Como*, 697 ft.; and the *Lake of Garda*, 227 ft.; they are larger than most of those on the N. of the Alps, and, with the advantage of an Italian climate, sky, and vegetation, they surpass the others in beauty, though the mountains that surround them are less lofty.[1]

---

[1] It appears that most of the Swiss lakes, and some of the Italian, had

These great lakes are fed by rivers rising in the glaciers of the higher Alps, and many large rivers issue from them. In this respect they differ from most of the lakes in Central and Southern Italy, some of which are craters of ancient volcanoes, or perhaps ancient craters of elevation, where the earth had been swelled up by subterranean vapour without bursting, and had sunk down again into a hollow when the internal pressure was removed.[1]

§ 3. **Asiatic Lakes.**—In Syria, the *Lake of Tiberias,* and the *Dead Sea*, memorials sacred to the Christian world, are situated in the deepest depression on the earth's surface, the bottom of the latter being 2606 ft. below the level of the ocean. The surface of Lake Tiberias is 620 ft. below that of the Mediterranean, surrounded by verdant plains; while the dense bitter waters of the Dead Sea, forming an expanse 42 m. long and from 12 to 16 m. wide, 1298 ft. below the Mediterranean, lie in a scene of great desolation and solitude, encompassed by desert sands, and bleak, stony salt hills. Thus there is a difference of level of 678 ft. in little more than 60 m., which renders the current of the Jordan very rapid. The water of the Dead Sea is so acrid, from the large proportion of saline matter it contains, that it irritates the skin; it is more buoyant, and has a greater proportion of salt, than any that is known except the small Lake Elton, E. of the Volga. 'The salt mountain of Jebel Usdum is the most interesting phenomenon about the lake—a long mass of rock salt, about 7 m. long, and from 1½ to 3 m. wide, several hundred ft. high, capped along its jagged top by a mass of gypsum and marl, extending S. from the S.W. corner of the lake. Through this salt mountain several streams percolate, continually bearing additional solutions of salt into the bitter and almost saturated waters. The water of the lake, where saltest, contains 28 parts of solid salt to 72 of water, but it varies much in different parts, owing to the inflow of fresh water.'[2] The

---

been inhabited by a primitive race of mankind of which no record remains, who built their huts upon stakes driven into the bottom of the lake, and thus lived on the surface of the water, probably as a refuge from enemies on land. Those stakes that are below the surface of the water were long known to the fishermen, who avoided them as destructive to their nets, but of late they have excited much interest on account of the numerous implements that have been found by excavating between the stakes. The custom is now followed by some tribes in the Pacific Islands, and on many parts of the River Zambesi the Africans build their huts on stakes 20 ft. above the ground, that in the rainy season they may not be endangered by the floods, which are constant and sudden. During this time it is not unusual for a native to indulge in the luxury of fishing out of his bed. In 1855 thousands of the natives were drowned by the river rising higher than usual.

[1] The Lakes of Perugia, or Thrasymene, and Fucino are exceptions.

[2] Tristram's 'Natural History of the Bible.'

Lake of Assal, in the Somali country, nearly opposite to Aden, resembles the Syrian lakes in many respects; its surface is 600 ft. below the sea level, and its area is 40 sq. m. Separated from the ocean by a barrier of lava, it probably owes its formation, like the Dead Sea, to a barrier raised by volcanic agency between it and the Red Sea at a comparatively recent period.

Though extensive sheets of water exist in many parts of Asia Minor, especially in Bithynia, yet the characteristic feature of the country, and of all the table-land of Western Asia and the adjacent steppes, is the number and magnitude of the saline lakes. A region of salt lakes and marshes extends at least 200 m. along the N. foot of the Taurus range, on a very elevated part of the table-land of Anatolia. There are also many detached lakes, some exceedingly saline. Fish cannot live in the *Lake of Toozla,* which is shallow and subject to excessive evaporation. Neither can any animal exist in the *Lake of Shahee or Urumiah,* on the confines of Persia and Armenia, 1730 sq. m. in area; its water is perfectly clear, and contains a fourth part of its weight of saline matter. These lakes are fed by springs, rain, and melted snow, and having no outlets the surplus water is carried off by evaporation.

It is possible that the volcanic soil of the table-land may be the cause of this exuberance of salt water. *Lake Van,* a sheet of salt water, 1413 sq. m. in area, is separated from the equally salt Lake Urumiah only by a low range of hills; there are many pieces of fresh water in that neighbourhood, possibly in similar hollows.

Persia is singularly destitute of water; the *Lake Seistan,* or Hamoon Swamp, on the frontiers and in Afghanistan, having an area of 3000 sq. m., is the only piece of water on the western part of the table-land of Iran.

It is evident from the saline nature of the soil and the shells it contains, that the plains around the *Caspian, Lake Aral,* and the steppes, even to the Ural Mountains, had once formed part of the Black Sea; 82,000 sq. m. of that country are depressed below the level of the ocean—a depression which extends northwards beyond the town of Saratov, 300 m. distant from the Caspian. Sir Roderick I. Murchison was of opinion that the great areas of land which surround the present Caspian, and which now separate it from Lake Aral, have been elevated into their present positions from a former great interior depression on the earth's surface. The surface of the Caspian itself, which is 86 ft. below the level of the ocean, is its lowest part, and has an area of 178,866 sq. m., nearly equal to that of Great Britain and Ireland. In Europe alone the Caspian drains an extent of 850,000 sq. m., receiving the Volga, the Ural, and other great rivers, on the N. It has no tide, and its

navigation is dangerous from heavy gales, especially from the S.E., which drive the water miles over the land: a vessel has been stranded 46 m. inland from the shore. It is 300 ft. deep in the centre, but is shallower to the E., where it contains several islands, and where it is bounded by impassable swamps many miles broad. It is less salt than the ocean. *Lake Elton*, 26 ft. below the level of the sea, on the steppe E. of the Volga, has an area of 78 sq. m., and furnishes two thirds of the salt consumed in Russia. Its water yields 29·13 per cent. of saline matter, and from this circumstance is more buoyant than any other known.[1]

Lake Aral, which is shallow, is 243 ft. higher than the Caspian, and has an area of 26,940 sq. m.: it has its name from the number of small islands at its southern end, Aral signifying 'island' in the Tartar language. Neither the Caspian nor Lake Aral has any outlets, though they receive large rivers; they are salt, and, in common with all the lakes in Persia, are decreasing in extent, and becoming salter, the quantity of water supplied by tributaries being less than that lost by evaporation. Most of the rivers that run into Lake Aral are diminished by canals, that carry off water for irrigation; for that reason a very small portion of the waters of the Oxus reaches the lake. Besides, the Russian rivers yield less water than formerly from the progress of cultivation. The small mountain lake *Siri Kul*, in the high table-land of Pamir, from whence the Oxus flows, is 15,600 ft. above the sea; consequently there is a difference of level between it and the Dead Sea of nearly 17,000 ft.

The small number of lakes in the Southern Himalayas is one of the peculiarities of these mountains. There are, however, many great lakes, both fresh and salt, on the plateau of Tibet; the annular form of *Lake Yamdok Cho*, N. of the S. Himalayas, is unexampled; it is 45 m. round, but only 2 or 3 wide. Within its circuit is a large island with hills of 2000 or 3000 ft. above its surface. Its waters are said to be sweet. The sacred lakes of *Manasarowar* and of *Rakas Tal*, in Great Tibet, occupy a space of about 720 sq. m., between the gigantic peaks of Gurla on the S. and of Kailas on the N.; it is from the most westerly of these lakes that the Sutlej rises, at an elevation of 15,250 ft. above the level of the sea. *Chomto Dong* and *Palgu Cho*, lying respectively to the N.E. and N.W. of Mount Everest, the former at an elevation of 14,700 ft., the latter somewhat higher, are the remaining principal lakes between the Brahmaputra and the S. Himalayas. From 2 to 3 degrees N. of the Brahmaputra, and running in the main

[1] The water of the Dead Sea contains 26·24 per cent. of saline ingredients, one of which is sulphate of magnesia.

parallel with it, lies the vast lacustrine Plateau of Tibet, stretching S.E. and N.W. between the parallels 30° and 34° N. lat. This plateau was traversed in 1874 and 1875 by the Pundit Nain Sing, one of Colonel Montgomerie's native explorers, and found to embrace a long chain of lakes, of which *Tengri Nur*, or *Namcho*, *Kyaring Cho*, *Chikul Cho*, *Dung Cho*, and *Dangra Yum Cho* are chief. All these lakes, except Tengri Nur, are new to geographers. They lie at great elevations, but are well stocked with fish. *Tengri Nur*, or Namcho, has an area of 720 sq. m., and lies at an elevation of 15,190 ft. On the S. it is flanked by the Ninjin-thanglá range, which is very high, runs more than 150 m. towards the N.E., and culminates in the great peak of *Jáng Ninjin-thanglá* (upwards of 25,000 ft.). It is considered a sacred lake, and has several Buddhist monasteries on its shores, which are visited by large numbers of pilgrims. The *Koko Nur* and *Lake Lop* are large, the former having an area of 900 sq. m., the latter an area of 700 sq. m., and there are others not inferior to these in the N. The lakes in the Altaï Mountains are large and beautiful. They are at different elevations on the terraces by which the table-land descends to the plains of Siberia, and are, owing to geological phenomena, essentially different from those which have produced the Caspian and other steppe lakes. They seem to have been hollows formed where the axes of the different branches of the chain cross, and are most numerous and deepest in the eastern Altaï. *Baikal*, the largest mountain lake, supposed to owe its origin to the sinking of the ground during an earthquake, has an area of 13,300 sq. m., nearly equal to the half of Scotland. It lies buried in the form of a crescent, amid lofty granite mountains, which constitute the edge of the table-land to the S., ending in the Desert of Gobi; in the N.W. the hills gird the shore so closely that they dip ino the water in many places: 160 rivers and streams fall into this lake, which drains a country probably twice the area of Britain. The River Angara, which runs deep and strong through a crevice at its eastern end, is its principal outlet, and is supposed to carry off but a small proportion of its water. Its surface is 1280 ft. above the sea level, and the climate is as severe as it is in Europe 10° farther N.; yet the lake does not freeze till the middle of December, possibly from its depth, being unfathomable in some places with a line of 600 ft.

Lake Saisan Nor spreads itself out in a broad and elevated valley, surrounded by mountain ranges on three of its sides; the Altaï on the N.E., the Kolbinsk on the N.W., and the Tarbagatai range on the S. side. The waters of the lake are transparent, soft, good for cooking purposes, and abound in fish. The lake is frozen over from November to May, and its level rises during June

and July on account of the swelling of the Black Irtysh, which flows into it from the E. The shores of the lake are marshy and overgrown with reeds. Besides the Black Irtysh, which has a length of 466 m., it receives more than 10 streams of considerable size. The White or Lower Irtysh flows out of the lake at the N.W. extremity, and is a deeper and fuller river than the Black Irtysh. The course of the latter is interrupted by falls and cataracts.

§ 4. **African Lakes.**—Very extensive lakes occur in Africa. In lat. 21° S. and E. long. 23° 20′ is situated *Lake Ngami*, which lies in the Kalahari Desert at an elevation of 2930 ft. above the sea, and has an area of 300 sq. m. It receives the Tioge River from the N.W., but has no outlet. The Zouga River comes from the salt lagoons, which lie to the S.E. of the lake, a circumstance which has given rise to the belief that the region is the old bed of a more extensive lacustrine basin. Abyssinia has the large and beautiful *Lake of Dembea*, or *Tsana*, situated in a spacious plain—the granary of the country—so high above the sea (6097 ft.) that spring is perpetual, though within the tropics, and covering an area of 1200 sq. m. There are many other lakes in this great projecting promontory, so full of rivers, mountains, and forests, including the picturesque *Lake Ashangi*, 8006 ft. above the sea, embosomed in mountains, on the eastern edge of the plateau. Due W. of this, near the centre of the broad northern portion of the continent, is *Lake Chad*, which lies at an elevation of 830 ft., and extends over an area of 14,500 sq. m. It receives the great River Shari from the S.E., and the Komadugu from the W. It has no outlet, but sends off its surplus waters by evaporation. Other lakes of less magnitude are known to exist in these regions, and there are probably many more that are unknown. Salt water lakes are numerous on the northern boundaries of the great lowland deserts, and many fine sheets of fresh water are found in the valleys and flat terraces of the Great and Little Atlas.

It is, however, in the equatorial part of the African interior where the largest of these sheets of inland water are found, and it is to the enterprise of English travellers during the last 25 years that we owe all that is known about them. The most southerly of these great lakes is *Nyassa*, discovered by Dr. Livingstone in 1859. It lies in a deep valley, trending N. and S., flanked by mountain ranges, in parts ranging from 10,000 to 12,000 ft. high, and distant 400 m. from the E. coast. Its length is about 350 m., its area about 9000 sq. m., and its elevation 1522 ft. The waters are clear, very deep, and of a dark blue colour, and abound in fish. In the dry season (July to December) the S.E. breeze blows with prodigious force up the lake, creating heavy waves and making its

navigation dangerous. A steamer was launched on the lake in October 1875 by Mr. E. D. Young, the leader of the 'Livingstonia Mission' to Lake Nyassa. During the course of a month's cruise Mr. Young found that the lake was much larger than Dr. Livingstone had conjectured, and that it extended N. to lat. 9° 20′ S.[1] Lofty rocky headlands diversify the shore scenery, and between them are lovely bays, fringed with sandy beaches. The lake receives the drainage of the surrounding mountain slopes, and has outlets at the Shiré, a tributary of the Zambesi at the S. end, and the Revoma at the N. end. About 260 m. to the N.W. of Nyassa lies *Lake Tanganyika*, discovered by Captains Burton and Speke in 1858. It lies in a deep valley 400 m. long, extending from N.W. to S.E., has an elevation of 2710 ft., and is hemmed in by highlands. It extends over an area of 12,600 sq. m. In 1867–8 Dr. Livingstone discovered a chain of smaller lakes to the S.W. and W. of Tanganyika, viz. *Bangweolo* or *Bemba*, *Moero*, and *Ulenge* or *Kamolondo*, now called *Lanji*, which are expansions of the River Chambeze—called between the two S. lakes Luapula, and N. of Moero, Lualaba. Lieut. Cameron, however, who visited this region in 1874, says that the true Lualaba is a river rising to the S.W. of Lake Bangweolo, which, after expanding into another series of lakes—viz. *Lohemba*, *Kassali*, *Kowamba*—lying W. of Livingstone's chain, joins Livingstone's Lualaba near Lake Ulenge.[2] Cameron also gives the Luvwa as the proper name of the river which flows between the Lakes Moero and Ulenge. N. of Tanganyika lies the vast expanse of *Albert Nyanza*, discovered by Sir Samuel Baker in 1864. At the point where the travellers first beheld this enormous sheet of water, from a high cliff on its E. shore, it appeared to be about 60 m. wide; while farther S. it was evidently broader. M. Gessi, a member of Col. Gordon's party, has recently (1876) circumnavigated the lake, and found it to be 140 m. long and 50 m. broad. Dense forests clothe its banks, and high mountains skirt its W. side. Its S. end is very shallow. The Nile issues from its N. end, and within 30 m. of the outlet the Albert receives the drainage of the *Victoria Nyanza* of Speke, the S. end of which he discovered in 1858, and which he again saw in 1862, when he was accompanied by Captain Grant. It lies at an elevation of 3800 ft. above the sea level, has an area of about 2800 sq. m., and sends its surplus waters N.W. into the Albert Nyanza by a river upwards of 200 m. in length, flowing in the latter part of its course with great rapidity, and finally leaping in a magnificent cascade to the

1 See the 'Geographical Magazine,' June 1876.

2 'Proceedings of Royal Geographical Society,' February 1876.

level of the Albert, a few miles above its junction with the lake. Thus it appears that in the centre of the torrid zone of the most torrid of continents, a system of fresh water lakes exists, little inferior to that of the Laurentian lakes of North America, hitherto considered by far the largest on the globe. Being surrounded by healthy highlands and fertile plateaux, and rendered accessible by the Nile, they afford unexpectedly means of opening up and developing the resources of the vast interior of the African continent.

§ 5. **American Lakes.**—A very large portion of North America is covered with fresh water; the five principal lakes—Superior, Huron, Michigan, Erie, and Ontario—with some of their dependents, cover an area of about 94,000 sq. m.; that of Lake Superior alone, 32,000 sq. m., which is only 1800 sq. m. less than the whole of England. Previous to the discovery of the lakes of equatorial Africa, the American lakes were held to contain two thirds of all the fresh water deposits on the globe. The altitude of these lakes shows the slope of the continent; the elevation of *Lake Superior* is 627 ft.; of *Lake Huron* 578 ft.; of *Lake Erie*, 565 ft.; and of *Lake Ontario*, 231 ft. The River Niagara, which unites the two last named lakes, is 33½ m. long, and in that distance it descends from the height of 565 ft. to that of 232 ft. above the sea level; but the upper part of its course is navigable. The height of the cascade of Niagara is 162 ft. on the American side of the central island, and 1125 ft. wide. On the Canadian side the fall is 149 ft. high, and 2100 ft. wide—a magnificent sheet of falling water, second only to that which goes over the falls of the Zambesi. The River St. Lawrence, which drains the whole, slopes 234 ft. between the bottom of the cascade and the sea. The bottom of Lake Superior is 300 ft., and that of Ontario 268 ft., below the surface of the Atlantic, affording another instance of deep indentation in the solid matter of the globe. Some lakes are decreasing in magnitude, though the contrary seems to be the case in America; between the years 1825 and 1838 Ontario rose nearly 7 ft.; and, according to the American engineers, Lake Erie had gained several feet in the same time. Lake Huron is said to be the focus of peculiar electrical phenomena, as thunder is constantly heard in one of its bays. The lakes N. of this group are innumerable; the whole country, to the Arctic Ocean, is covered with sheets of water. *Lake Winnipeg*, *Reindeer Lake*, *Slave Lake*, and some others, may be regarded as the chief members of separate groups or basins, each embracing a wide extent of almost unexplored country. There are also many lakes on each side of the Rocky Mountains: one of the most remarkable is the *Great Salt Lake*, on the plateau of the Great Basin between the Wahsatch and the Humboldt ranges, whose surface has an elevation of 4210 ft. above the level

of the sea; it has several islands, its waters contain 22 per cent. of salts, chiefly muriate of soda, and its area is 1630 sq. m.: the neighbouring *Lake of Utah* (4790 ft.) is fresh, and empties itself into the Great Salt Lake by a river called the Jordan. In Mexico there are 6 or 7 lakes of considerable size, though not to be compared with those in North America.

There are many sheets of water in Central America, though only one is of any magnitude, the Lake of Nicaragua, in the province of that name, about 100 m. from the sea, which communicates with the Gulf of Mexico by the River of San Juan.

In Central America the Andes are interrupted by plains and mere hills on the Isthmus of Tehuantepec and of Nicaragua, on each side of which there is a series of lakes and rivers, which, aided by canals, might form a water communication between the Atlantic and Pacific Oceans. In the former, the line proposed would connect the River Goazacoalcos, on the Gulf of Mexico, with the Bay of Tehuantepec, in the Pacific. In the Isthmus of Nicaragua, the Gulf of San Juan would be connected by the river of that name, and the chain of lakes of Nicaragua and Leon, with the Bay of Realejo or the Gulf of Fonseca, with the Gulf of Costa Rica. Here the highest level necessary would be 212 ft. above the Pacific, and of easy excavation; and the lake, situate in an extensive plain, and at an elevation of 125½ ft. above the sea, is deep enough for vessels of considerable size.[1]

A range of lakes goes along the eastern base of the Andes; but the greater part of them are mere lagoons or marshes, some very large, which inundate the country to a great extent in the time of the tropical rains. There appears to be a deep hollow in the surface of the earth at the part where Bolivia, Brazil, and Paraguay meet, in which lies the *Lake Xarayos*, extending on each side of the River Paraguay; but, like many South American lakes, it is not permanent, being alternately inundated and dry, or a marsh. Its inundations cover 36,000 sq. m. Salt and fresh water lakes are numerous on the plains of La Plata, and near the Andes in Patagonia, resembling in this respect those in high northern latitudes, though on a smaller scale.

In the elevated mountain valleys and table-lands of the Andes there are many small lakes of the purest blue and green colours, intensely cold, some being near the line of perpetual congelation.

---

[1] The reader is referred to a paper published by Admiral FitzRoy in the 20th vol. of the 'Journal of the Geographical Society,' for a lucid description and review of the different projected canals and routes across the American isthmus, viz., by the Lake Nicaragua, the River of Goazacoalcos, and the Isthmuses of Panamá and Darien.

They are generally of considerable depth. The great fresh water lake of *Titicaca*, however, in the Bolivian Andes, has an area of 3200 sq. m., and is more than 120 fathoms deep in many places, surrounded by splendid scenery. Though 12,493 ft. above the level of the Pacific, and consequently higher than the Peak of Teneriffe, it contains several species of fish; its shores are cultivated, producing corn, barley, potatoes, and even Indian corn; and peopled by a large aboriginal population, inhabiting towns and villages. Numerous vestiges of Peruvian civilisation are everywhere to be met with; and in the island from which it derives its name, and where tradition places the origin of the last Inca dynasty, numerous specimens of Peruvian architecture still exist. It receives several rivers from either branch of the Andes, but has only one exit, the River Desaguadero, the waters of which are lost by evaporation and infiltration in the sandy soil through which it flows, and in its terminal lake or marsh of Aullagas.[1]

The limpid transparency of the water in lakes, especially in mountainous countries, is remarkable; minute objects are visible at the bottom through many fathoms of water. The vivid green tints so often observed in Alpine lakes may be produced by vegetable dyes dissolved in the water, though chemical analysis has not detected them.

Lakes, being the sources of some of the largest rivers, are of great importance for inland navigation as well as for irrigation; while, by the constant evaporation at their surface, they maintain the supply of humidity in the atmosphere so essential to vegetation.

CHAPTER XXIII.

ATMOSPHERIC PHENOMENA.

§ 1. **Height and Composition of the Atmosphere.**—The atmosphere completely envelopes the earth to a height which is variously estimated at from 27½ to upwards of 100 m.; it bulges at the equator, and is flattened at the poles, in consequence of the diurnal rotation. It is a mixture of water in an invisible state and of air, but the air is not homogeneous: in 100 parts, 79 consist of nitrogen gas, and 21 of oxygen, the latter the source of combustion and animal heat, and 0·45 of water. Besides these, there is a small quantity of carbonic acid gas, varying from 3 to 5 ten thousandths,

[1] See Pentland's map of the Lake of Titicaca, published at the Hyd. Office in 1847.

which is sufficient to supply all the vegetation on the earth with wood and leaves, and a very minute proportion of ammoniacal gas.[1] Ozone, discovered in 1848 by Professor Schönbein, of Basle, is also a constituent of the atmosphere. It is a form of oxygen, produced by the passage of electricity through the air, or by the action of phosphorus on damp air. Oxygen may be transformed into ozone by the electric machine, and is constantly being produced by the electricity in the atmosphere, and especially by lightning during thunderstorms. The peculiar smell produced when objects are struck by lightning is owing to ozone. It is a great purifier of the air, uniting with the gases arising from decaying organic matter, and depriving them of their hurtful qualities. It is more abundant on the sea coast than inland; on the W. than on the E. of Britain; on elevated than in low situations; with S.W. than with N.E. winds; in the country than in towns; on the windward than on the leeward side of towns. In our own country it is most abundant from February to June, and least from July to January. It reaches its maximum in May, and its minimum in November. The nitrogen and oxygen of the air are only in a state of unchemical moisture and not of chemical combination. This fact is proved in various ways, one of the most striking being the circumstance that water absorbs more oxygen from the air than nitrogen, the amount of the two gases found in water being in exact proportion to the absorptive power of that fluid for each of them separately. If air were a chemical compound, the ratio of the mixed gases absorbed by the water would be preserved. Exhalations of various kinds ascend into the air, such as those which produce miasmata; but they are in quantities too minute to be detected by chemical analysis, so that the atmosphere is found to be of the same composition at all heights above the sea hitherto attained. In addition to this, it may be stated that the property possessed by gases of readily mixing with each other without regard to their respective specific gravities is a benign provision for preventing the accumulation of injurious exhalations. Thus the carbonic acid arising from the decay of organised substances, although half as heavy again as atmospheric air, diffuses into the higher regions of the atmosphere with great rapidity.

---

[1] The researches of M. Ville show that the quantity of ammoniacal vapour in the air is so very minute as to exercise no influence, as was supposed by Liebig, on vegetation. M. Lewy has found that in some situations, as at Bogota, the proportion of carbonic acid gas varies with the seasons: thus, in 11 months out of the 12, the air contains the ordinary quantity, from $\frac{3}{10000}$ to $\frac{5}{10000}$ of its volume, whereas in September this proportion increases to $\frac{47}{10000}$, a circumstance quite inexplicable in the present state of meteorology.

The temperature of the earth's surface and the phenomena of the atmosphere depend upon the revolution and rotation of the globe, which successively expose all the parts of it, and the air which surrounds it, to a perpetual variation of the gravitating forces of the two great luminaries, and to annual and diurnal vicissitudes of solar heat. Atmospheric phenomena are consequently periodical and connected with one another, and their harmony and the regularity of the laws which govern them become the more evident in proportion as the mean values of their vicissitudes are determined from simultaneous observations made over widely extended tracts of the globe. The fickleness of the wind and weather is proverbial; but as nearly the same quantity of heat is annually received from the sun, and annually radiated into space, it follows that all climates on the earth are stable, and that their changes, like the perturbations of the planets, are limited and accomplished in fixed cycles, the periods of which are still in many instances unknown. It is possible, however, that the earth and air may be affected by secular variations of temperature during the progress of the solar system through space, or from periodical changes in the sun's light and heat, similar to those which take place in many of the fixed stars. The spots on the sun must occasion periodical variations both in the light and heat of the sun. The secular variation in the moon's mean distance will, no doubt, alter the amount of her attractive force, though probably by a quantity inappreciable in the aërial tides: at all events, variations arising from such circumstances could only become perceptible after many ages.

From experiments made by M. Peltier it appears that, if the absolute quantity of heat annually received by the earth were equally dispersed over its surface, it would in the course of a year melt a stratum of ice 46 ft. deep enveloping the whole globe. It is evident that, if so great a quantity of heat had been continually accumulated in the earth, instead of being radiated into space, it would have been transmitted through the surface to the poles, where it would have melted the ice, and the torrid zone, if not the whole globe, would by this time have been uninhabitable. In fact, every surface absorbs and radiates heat at the same time, and the power of radiation is always equal to the power of absorption; for, under the same circumstances, bodies which become soon warm also cool rapidly; and the earth, as a whole, is under the same law as the bodies at its surface.

Oxygen and nitrogen are the most permeable of all gases to radiant heat; hence our atmosphere readily transmits solar heat. The presence of vapour, however, moderates the effects of radiation.

According to Professor Tyndall, so enormous is the absorbent power of aqueous vapour, that 10 per cent. of the terrestrial radia-

tion is stopped within 10 feet above the surface of the ground in England, and were the aqueous vapour which floats in our atmosphere removed for one summer night, every plant would be destroyed by the freezing temperature.

Although part of the heat received from the sun in summer is radiated back again, by far the greater part sinks into the earth's surface, and tempers the severity of the winter's cold while passing through the atmosphere into the ethereal regions.

The earth is about 3,000,000 m. nearer to the sun in winter than in summer, but the rays strike the northern hemisphere more obliquely in winter than in the other half of the year; and Professor Secchi has shown that on that account the atmosphere absorbs more of the sun's heat in winter than in summer. At Rome, in the finest season of the year, he found that when the sun is in the zenith the atmosphere absorbs one fourth of the heat during the vertical transit of his rays; when they fall at the distance of 60° from the zenith, the loss is one half, and continues to be very rapid as the obliquity increases. Thus the difference between the summer and winter temperature depends chiefly on the absorbing power of the atmosphere. The Professor observes that the absorbed heat is not lost, but supplies the greater part of that which is radiated into space.

Sir John Herschel has shown that the elliptical form of the earth's orbit has but a trifling share in producing the variation of temperature corresponding to the difference of seasons; for although in one half of its orbit the earth is nearer the sun than in the other half, its motion is so much more rapid in the former than in the latter, that it is exposed for a shorter time to the sun's influence; thus a compensation takes place, and an equal distribution of light and heat is accorded to both hemispheres.

But on account of the present position of the earth's orbit, the *direct* heating power of the sun in summer is greater by nearly one eighteenth of its whole intensity in the southern than in the northern hemisphere in equal latitudes and under equal circumstances of exposure; for that reason the sufferings of travellers in the southern deserts are much more intolerable than in the northern. In the account of the exploring expedition into the interior of Australia, Captain Stuart mentions that 'the ground was almost a molten surface; and if a match accidentally fell on it, it immediately ignited.' Sir John Herschel has observed the temperature of the surface soil in South Africa as high as 159° Fahr.[1] By direct experiments made at Rome, Professor Secchi found that a thermometer exposed to the sun in an open field, and slightly covered

[1] Sir J. Herschel's 'Outlines of Astronomy,' p. 218, 1849.

with earth, rose to 150°·6 Fahr. at half past one o'clock in the month of July, which differs only by 8°·4 from that of South Africa.

Diurnal variations of heat are perceptible only to a small distance below the surface of the ground, because the earth is a bad conductor: the annual influence of the sun penetrates much farther; at the equator, where the heat is greatest, it descends deeper than elsewhere, with a diminishing intensity; but there, and everywhere throughout the globe, there is a stratum at a depth varying from 40 to 100 ft. below the surface of the ground, where the temperature never varies, and is nearly the same as the mean temperature of the country. This zone, unaffected by the sun's heat from above, or by the internal heat from below, serves as an origin whence the effects of solar heat are estimated on one hand, and the internal temperature of the globe on the other. Below it the heat of the earth increases, as already mentioned, at the rate of 1° Fahr. for every 50 ft. of perpendicular depth; were it to continue increasing at that rate, every substance would be in a state of fusion at the depth of 21 m.; hitherto, however, the experiments in mines and artesian wells, whence the earth's temperature below the constant stratum is ascertained, have not been extended below 1700 ft.[1]

---

[1] The protuberant matter at the earth's equator occasions a nutation in the lunar orbit, and the action of the sun and moon on that protuberant matter produces those inequalities in the earth's rotation known as the Luni-Solar Nutation and Precession. (See 'Connexion of Physical Sciences,' sections 5 and 11.) These inequalities have been computed on the hypothesis of the earth being a solid mass. Mr. Hopkins found that the result would be the same if the earth consisted of a solid shell, enclosing a nucleus of liquid fire, provided the shell were from 800 to 1000 miles in thickness. According to the actual increase of internal heat, the earth must be in fusion at the depth of 21 m., a circumstance equally inconsistent with the preceding result, and with the amount of precession. However, the temperature at which fusion takes place is probably different at different depths on account of the enormous pressure. (See 'Connexion of Physical Sciences.') Now Mr. Hopkins showed that, if the pressure has no effect in increasing the temperature of fusion, the existing temperature cannot be due to original central heat; but if it does affect it, then, along with the increasing tendency of heat to prevent solidification as the depth increases, there would be an increasing tendency to promote it, by rendering the mass fusible at a higher temperature. According as one or other of these tendencies predominates, different cases occur; consequently the internal state of the globe may be determined by experiments on the effect of high pressure on the temperature of fusion. Were the earth composed of a solid shell filled with fluid matter, the lava would stand at the same height in all volcanoes, which it does not; and the same would happen if the globe had a solid nucleus from high pressure, and a solid crust from refrigeration, with matter between, which is one of the possible cases arising from Mr.

M. Elie de Beaumont has estimated by the theory of Fourier, and from the observations of M. Arago, that the quantity of central heat which reaches the surface of the earth is capable, in the course of a year, of melting a shell of ice a quarter of an inch thick[1] covering the globe.

The superficial temperature of the earth is great at the equator, it decreases gradually towards the poles, and is an exact mean between the two at the 45th parallel of latitude; but a multitude of causes disturb this law, even between the tropics. It is affected chiefly by the unequal distribution of land and water, by the height above the sea, by the nature of the soil, and by vegetation; so that a line drawn on a map through all the places where the mean temperature of the earth is the same would be very far from coinciding with the parallels of latitude, but would approximate more to them as it approaches the equator. Between the tropics the temperature of the earth's surface is greater in the interior of continents than on the sea coasts and islands, and in the interior of Africa it is greater than in any other part of the globe.

Temperature depends upon the property all bodies possess, more or less, of perpetually absorbing and emitting or radiating heat. When the interchange is equal the temperature of a substance remains the same; but when the radiation exceeds the absorption, it becomes colder, and *vice versâ*. The temperature of the air is certainly raised by the passage of the solar heat through it, because it absorbs one third of it before reaching the earth, but it is chiefly warmed by heat transmitted and radiated from the earth. The radiation is abundant when the sky is still, clear, and blue, but clouds intercept it; so that a thermometer rises in cloudy weather, and sinks when the air becomes clear and calm; even a slight mist diminishes radiation from the earth, because it returns as much heat as it receives. The temperature of the air is subject to such irregularities from these circumstances, from the difference in the radiating powers of the bodies at the surface of the globe, that it is necessary to find by experiment the mean or average warmth of the day, month, and year, at a great variety of places, in order to have a standard by which the temperature in different parallels of latitude may be compared.

Hopkins's investigation. He shows, however, that from various circumstances the solid nucleus and the solid crust may be so united at intervals as to divide the molten matter into basins or seas of lava, which may be at different levels below the surface—a state that agrees better than any other with the phenomena of volcanoes. Professor Belli, of Pavia, thinks that in different volcanoes the lava stands at equal heights.

[1] 'Annales des Sciences Géologiques,' par M. Rivière, 1842.

An approximation to the mean diurnal temperature of the air at any place is equal to half the sum of the greatest and least heights of the thermometer during 24 hours; and as the height of the thermometer is twice, in the course of that time, equal to the mean temperature of the place of observation, it might seem easy to obtain its value; yet that is not the case, for a small error in observation produces a very great one in such minute quantities, so that accuracy can only be attained from the average of a great number of observations, by which the errors, sometimes in excess and sometimes in defect, neutralise or balance each other. The mean value of quantities is a powerful aid to the imperfections of our nature in arriving at truth in physical inquiries, and in none more than in atmospheric phenomena. Almost all the certain knowledge man has acquired with regard to the density and temperature of the air, winds, rain, &c., has been acquired by that method.

The mean temperature of any one month at the same place differs from one year to another, but the mean temperature of the whole year remains nearly the same, especially when the average of a great number of years is taken into consideration; for although the temperature in any one place may be subject to very great variations, yet it never deviates more than a few degrees from its mean state.[1]

The motion of the sun in the ecliptic occasions perpetual variations in the length of the day, and in the direction of his rays with regard to the earth; yet, as the cause is periodic, the mean annual temperature from the sun's motion alone must be constant in each parallel of latitude. For it is evident that the accumulation of heat in the long days of summer, which is but little diminished by radiation during the short nights, is balanced by the small quantity of heat received during the short days of winter and its radiation in the long frosty and clear nights.[2] Were the different parts of the globe everywhere on a level with the surface of the sea, and of

---

[1] The mean of any number of unequal quantities is equal to their sum divided by their number. To ascertain the mean annual temperature at any place accurately, the mean of a great number of years must be taken.

[2] The warmest time of the day is between two and three in the afternoon; the coldest, shortly before sunrise; but on mountain tops, where the effects of radiation from the ground are comparatively small, the time of greatest warmth depends on the direct rays of the sun, and is therefore a little before noon. The maximum annual temperature occurs about the middle of July in the northern hemisphere, the minimum is in January; so that the former takes place some time after the summer solstice, because the earth absorbs more heat than it radiates during that interval, and for the contrary reason the greatest cold is some time after the winter solstice; the mean takes place in April and October.

uniform substance, so as to absorb and radiate heat equally, the mean heat of the sun would be regularly distributed over its surface in zones of equal annual temperature parallel to the equator, and would decrease regularly to each pole. The distribution of heat, however, in the same parallel is very irregular in all latitudes, even between the tropics, from the inequalities in the level and nature of the surface of the earth, so that lines drawn on a map through all places having the same mean annual temperature are nearly parallel to the equator only between the tropics; in all other latitudes they deviate greatly from it, and from one another.[1] Radiation is the principal modifying cause of temperature; hence the heat of the air is most powerfully modified by the ocean, which occupies three times as much of the surface of the globe as the land, and is more uniform in its surface and also in its radiating power. Its volume is 400 times greater than that of the atmosphere, and the evaporation over its surface is so great that were it not restored it would depress its level about 5 ft. annually; the quantity of heat absorbed in this manner, and again liberated during rain, is enormous. On the land the difference in the radiating force of the mountains and table-lands from that of the plains—of deserts from grounds covered with rich vegetation—of wet land from dry, is the most general cause of variation.

There are two points in the northern hemisphere, both in the 80th parallel of latitude, where the cold is more intense than in any other part of the globe with which we are acquainted. One N. of Canada, in 80° N. lat. and 100° W. long., has a mean temperature of $-3°{\cdot}5$ Fahr.; while at the Siberian point, in 95° E. long., the mean temperature of the air is $+1°$; consequently it is $4\frac{1}{2}°$ warmer than that N. of Canada—a difference that has an influence even to the equator, where the mean temperature of the air is different in different longitudes. Sir David Brewster computed that the mean temperature of the North Pole of the earth's rotation is not under 5° Fahr., and may be even 17°, supposing the ocean to extend so far, which there is every reason to believe that it does; but M. Arago's estimate on the hypothesis of there being land at the North Pole makes the cold much greater, for land increases the cold by abstracting heat from the air in high latitudes, and augments the heat by radiation in low latitudes.

The line of the maximum temperature of the atmosphere, or the atmospheric thermal equator, which cuts the terrestrial equator in the meridians of Tahiti and Singapore, passing through the Pacific in its southern course, and through the Atlantic in its northern,

---

[1] Lines drawn on a map or globe through all places where the mean annual temperature is the same are called *isothermal lines.*

has a mean temperature of 83°·84 Fahr. But by the comparison of many observations the mean equatorial temperature of the air is 82°·94 in Asia, 85°·10 in Africa, and 80°·96 in America; thus it appears that tropical Africa is the hottest region on earth. Moreover, the atmosphere in the tropical zone of the Pacific, when free from currents, is $2\frac{1}{4}$° warmer than the corresponding zone in the Atlantic, which is 82°·40. Local circumstances increase both heat and cold immensely; in the Nubian Desert, for example, a heat of 150° Fahr. in the sun, and 130° in the shade, has been observed. Perhaps the greatest degree of heat on record was that experienced by Captain Griffiths near the Euphrates, where the thermometer stood at 156° in the sun, and 132° in the shade. In December 1738, at Kiringa, in Siberia, Gmelin is said to have experienced cold of −80°; the gentlest breeze would have rendered that cold fatal by the rapid abstraction of heat from the body. In December 1866, at Nulato, a post of the Russian Fur Company, on the Lower Yukon, the thermometer fell to −58° Fahr., 90° below freezing. In March 1876 the thermometer on board the 'Alert' registered −73·7° Fahr., or nearly 106° below freezing point.[1]

On account of the great extent of ocean, the isothermal lines in the southern hemisphere coincide more nearly with the parallels of latitude than in the northern. In the Pacific Ocean the only flexure is occasioned by the cold of the S. polar current, which flows along the western coast of the American continent. In the northern hemisphere the predominance of land and its frequent alternations with water, the prevalence of particular winds, irregularities of the surface, and the difference in the temperature of the points of maximum cold, cause the isothermal lines to deviate more from the parallels of latitude. They make two deep bends northward, one in the Northern Atlantic and another in the N.W. of America, and at last they separate into two parts and encircle the points of maximum cold.

Professor Dove has shown that in consequence of the excess of land in the northern hemisphere and the difference in the effect produced by the sun's heat according as it falls on a solid or liquid surface, there is an annual variation in the aggregate mean temperature at the surface of the earth, whose maximum takes place during the sun's northern declination, and its minimum during its southern.[2]

---

[1] See Captain Nares' Report to the Lords Commissioners of the Admiralty, November 1876.

[2] For example, Professor Dove found that the mean temperature of December, January, and February, at Toronto, in Canada, added to the

§ 2. **Climates.**—Places having the same mean annual temperature often differ materially in climate: in some the winters are mild and the summers cool, whereas in others the extremes of heat and cold prevail. England is an example of the first; Quebec, St. Petersburg, and the Arctic regions are instances of the second kind. The solar heat penetrates more abundantly and deeper into the sea than into the land; in winter the sea preserves a considerable portion of that which it receives in summer, and from its saltness does not freeze so soon as fresh water; hence the ocean is not liable to the same changes of temperature as the land, and by imparting its heat to the winds it diminishes the severity of the climate on the coasts and in islands, which are never subject to such extremes of temperature as are experienced in the interior of continents. The difference between the influence of sea and land is strikingly exemplified in the high latitudes of the two hemispheres. In consequence of the unbounded extent of the ocean in the south, the air is so mild and moist that a rich vegetation covers the ground; while in the corresponding latitudes in the N. the country is barren from the excess of land towards the Polar Ocean, which renders the air dry and cold. A superabundance of land in the equatorial regions, on the contrary, raises the temperature, while the sea moderates it.

Professor Dove has shown, from a comparison of observations, that Northern and Central Asia have what may be termed a true *Continental Climate* both in summer and in winter—that is to say, a hot summer and a cold winter; that Europe has a true *Insular* or sea climate in both seasons, the summers being cool and the winters mild; and that in North America the climate is inclined to be continental in winter and insular in summer. The extremes of temperature in the year are greater in Central Asia than in North America, and greater in North America than in Europe, and that difference increases everywhere with the latitude. In Guiana, within the tropics, the difference between the hottest and coldest months in the year is only 20°·2 Fahr.; in the temperate zone it varies from 20° to 50°; and at Yakutsk, in Siberia, it is 106°. Even in places which have the same latitude as in Northern Asia, compared with others in Europe or North America, the difference is very great. At Quebec the summers are as warm as those in Paris, and grapes sometimes ripen in the open air, yet the winters are as

mean temperature of the same months at Hobart Town, in Tasmania, exceeds the sum of the mean temperature of June, July, and August, at the same places, added together, by 22°·7 Fahr. Similar results, though varying in amount, were obtained for many corresponding stations in the two hemispheres, which establishes the law given in the text.

severe as those in St. Petersburg. In short, lines drawn on a map through places having the same mean summer or winter temperature are neither parallel to one another nor to the isothermal or isogeothermal lines, and they differ still more from the parallels of latitude.[1]

Observations tend to prove that all the climates on the earth are stable, and have remained so from the remotest historical periods; and that their vicissitudes are only oscillations of greater or less extent, which vanish in the mean annual temperature of a sufficient number of years. There may be a succession of cold summers and mild winters, but in some other country the contrary takes place; the distribution of heat may vary from a variety of circumstances, but the absolute quantity gained and lost by the whole earth in the course of a year is invariably the same.[2]

Since the air receives its warmth chiefly from the earth, its temperature diminishes with the height so rapidly that at a very small elevation the cold becomes excessive, as the perpetual snow on the mountain tops clearly shows. Besides, as the warm air ascends it expands, and its capacity for heat being increased more is absorbed, which gradually diminishes the sensible heat shown by the thermometer; the decrease is nearly at the rate of 1° Fahr. for every 300 ft. By computations founded on the capacity of the air for heat, and absorption of the solar light in the atmosphere, Fourier has estimated the temperature of the ethereal

---

[1] In the same manner as *isothermal lines* are supposed to pass through all parts of the globe where the mean temperature of the air is the same, so the *isogeothermal lines* are supposed to pass through all places where the mean heat of the ground is the same: the isothermal lines are supposed to be drawn through all places having the same mean summer temperature; and the *isochimenal lines* pass through all places where the mean winter temperature is the same. The practice of representing to the eye these lines on a map or terrestrial globe is of great use in following and understanding the complicated phenomena of temperature and magnetism.

[2] According to the researches of M. Arago, the climate of France has not altered since a century before the Christian era, that is, in a period of nearly 2000 years; and M. Dureau de la Malle has arrived at the conclusion that the climate of Italy has not varied from the time of Cato the Censor, who died 147 years before Christ, to the present time, or in 20 centuries, by comparing the times of ripening of different vegetables and plants, the periods of the vintage, and of the harvest, as given in the writings of Varro, Columella, &c., with the ripenings and harvests as they take place at present, and in the same localities.—Dureau de la Malle 'Sur la Climatologie &c., de l'Italie, &c.,' Paris 1850, 8vo. It has been established, by actual observation of the thermometer, that the climate of Central Italy has not varied since the time of Galileo, 220 years ago.

regions to be $-50°$ Fahr., while M. Pouillet makes $-220°$ from direct experiments on the radiation of terrestrial heat into a clear blue sky during the night. Sir John Herschel supposed it to be about $-239°$.

§ 3. **Density of the Atmosphere.**—The atmosphere, being a heavy and elastic fluid, decreases in density upwards, according to a determinate law, so rapidly that three fourths of the whole air which constitutes it are within four miles of the earth, and all the phenomena perceptible to us—as clouds, rain, snow, and thunder—occur within that limit. The air even on the tops of mountains is so rare as to diminish the intensity of sound, to affect respiration, and to occasion a loss of muscular strength in man and animals.[1]

Since the space in the top of the tube of a barometer is a vacuum, the column of mercury is supported in the tube by the pressure of the atmosphere on the surface of the mercury in the cistern: hence every variation in the density or height of the atmosphere occasions a corresponding rise or fall in the barometric column. The actual mean pressure of the atmosphere at the level of the sea is between 14½ and 15 pounds on the square inch; hence the pressure on the whole earth is enormous. It is equal to the weight of a solid globe of lead 60 m. in diameter.

The decrease in the density of the air affords an accurate method of finding the height of mountains above the level of the sea, which would be very simple, were it not for changes of temperature and moisture, which alter the amount of the pressure and interfere with the regularity of the law of its decrease. But as the heat of the air, as before stated, diminishes with the height above the earth at the rate of 1° Fahr. for every 300 ft., tables are constructed by the aid of which heights may be determined with considerable accuracy. In consequence also of diminished pressure, water boils at a lower temperature on mountain tops than at the level of the sea, which affords another method, although less exact, of ascertaining heights.[2]

---

[1] If the heights above the earth increase by equal quantities, as a foot or a mile, the densities of the strata of air, or the heights of the barometer which are proportional to them, will decrease in geometrical progression: for example, if the height of the barometer at the level of the sea be 29·922 inches, it will be 14·961 inches at the height of 18,000 feet, or one half as great; it will be one fourth as great at the height of 36,000 feet, one eighth at the height of 54,000 feet, and so on.

[2] The *Aneroid Barometer*, invented by M. Vidi, of Paris, although not to be compared as an instrument of precision with the ordinary mercurial barometer, is infinitely more portable, and gives with promptitude and

By the annual and diurnal revolutions of the earth, each column of air is alternately exposed to the heat and cold of summer and winter, of day and night; and also to variations occasioned by the attraction of the moon, producing tides similar to those of the ocean, although in a less marked degree. These lunar tides ebb and flow twice during a lunation; their extent has been satisfactorily determined at stations within the tropics. Variations to a much larger extent are produced by the action of the sun's heat on the atmosphere; they accomplish their rise and fall twice in the 24 hours, and are entirely due to the effects of temperature on the air and the moisture contained in it, by which, according to Mr. Dove's researches, independent pressures on the mercurial column in the barometer are occasioned.[1]

A quantity of vapour is continually raised by the heat of the sun from the surface of the globe, which mixes in an invisible state with the dry air or gaseous part of the atmosphere. It is most abundant in the torrid zone and, like the heat on which it depends, varies with the latitude, the season of the year, the time of the day, the elevation above the sea, and also with the nature of the soil, the land, and the water. There is no chemical combination between the aërial and aqueous atmospheres, they are merely mixed; and the diurnal variations arise from the superposition of two distinct diurnal oscillations, each going through its complete period in 24 hours; one taking place in the aërial atmosphere from the alternate heating and cooling of the air which produce a flux and reflux over the point of observation; the other arising from the aqueous atmosphere, owing to the alternate production and destruction of vapour by the heat of the day and the cold of the night. The diurnal variations of the vapour have their maximum at or near the hottest hour of the day, and their minimum at or near the coldest, which is exactly the converse of the diurnal variations of the dry air. On

accuracy small differences of pressure; it will be found, under proper precautions, and comparison from time to time with the mercurial barometer, a most useful companion to the traveller in mountain districts. The observations can be made in a couple of minutes.

[1] The moon's orbit is very much elongated, so that her distance from the earth varies considerably, and consequently her attractive force. Moreover, her attraction varies with the rotation of the earth, which brings her twice in 24 hours in the meridian of any place, once in the superior and once in the inferior meridian; but her attractive action on the atmosphere is much inferior to that of the sun. The amount of the moon's attractive force on the atmosphere was first deduced by General Sabine ('Phil. Trans.' 1847 and 1852) from the observations made at the Colonial Observatories of St. Helena and Singapore, and found by him to be 0·570 of an inch in lat. 1° 3′, and 0·365 in 16°.

the whole there are two maxima and two minima heights of the barometer in the course of 24 hours from the combinations of these; but in the interior of continents far from water, where the air is very dry, there ought to be one maximum and one minimum during that period according to this theory. That appears to be actually the case in some parts of Asiatic Siberia, and of the interior of North America during the winter season, when there is scarcely any aqueous vapour present in the atmosphere.

Between the tropics the barometer attains its greatest height at half past nine in the morning; it then sinks till half past four in the afternoon, after which it again rises and attains a second maximum at half past ten in the evening; it then begins to fall till it reaches a second time its lowest point at half past three in the morning. The mean difference in the height is 0·117 of an inch, which gradually decreases N. and S. Humboldt mentions that the diurnal variations of the barometric pressure are so regular between the tropics that the hour of the day may be inferred from the height of the mercury to within 15 or 16 minutes, and that it is undisturbed by rain, or earthquake, both on the coasts and at altitudes 13,000 ft. above them. Among the results obtained at Kew from observations made during numerous voyages, it appears that between 5° and 10° N. lat. the range of the barometer is so small and so regular as to time, that a barometer may be verified in crossing that zone with perfect confidence. The mean height of the barometer between the tropics at the level of the sea is 30 inches with very little fluctuation, but, owing to the ascending currents of air from the heat of the earth, it is less under the equator than in temperate zones, and the decrease towards the equator is extremely regular. It attains a maximum in Western Europe between the parallels of 40° and 45°; in the North Atlantic the maximum is about the 30th parallel, and in the southern part of that ocean it is near the tropic of Capricorn; the amplitude of the oscillations decreases from the tropics to about the 70th parallel, where the diurnal variations cease. They are affected by the seasons, being greatest in summer and least in winter. It appears also that the fluctuations are the reverse on mountain tops from what they are on the plains, and probably at a certain height they would cease altogether.[1] It is a singular fact, discovered during Sir James C.

[1] Mr. Pentland, however, found within the tropics, in the Peru-Bolivian Andes, at elevations between 11,000 and 14,000 ft., the horary oscillations of the barometer as regular, and nearly as extensive, as on the level of the sea in the same latitude; they have also been found to observe the same regularity at still more elevated stations in the Himalayas, although the extent of the oscillation was less, owing possibly to the extra-tropical position of that region.

Ross's last voyage, that the mean height of the barometer is lower throughout the Antarctic Ocean and at Cape Horn than it is at the Cape of Good Hope or Valparaiso. It depends upon there being less air and more vapour in the southern than in the northern hemisphere. For the enormous quantity of vapour raised by evaporation from that vast expanse of ocean permanently expels a large portion of the atmosphere, just as steam expels air from a boiler, and that is proved by the mean height of the barometer being 30·1 between the equator and 78° 37′ N. lat., while its mean height in 70° S. lat. is only 29·0. Hence the depression observed by Sir James Ross. A similar depression near the Sea of Okhotsk, in Eastern Siberia, is recorded by M. Ermann. But in this case it is the cold that condenses the vapour into clouds, heat being liberated, which swells out the superincumbent air and diminishes the pressure. Mr. Buchan, the Secretary of the Scottish Meteorological Society, found that in July the lowest pressures are distributed over the continents, and the larger the continental mass the greater the depression, and that the high pressures are distributed over the oceans, between 50° N. and 50° S. lat., the highest pressures occurring in those parts of the ocean which are most completely enclosed by the continents. In January, on the contrary, the *isobaric lines* show a pressure above the average which is almost confined to the northern hemisphere, and is highest of all in Central and Northern Asia, while a low pressure prevails in the southern hemisphere and in the North Atlantic, having its greatest depression in Iceland. The mean annual atmospheric pressure shows two regions of high pressure passing round the earth in broad belts to the N. and S. of the equator. Between them is the tropical belt of low pressure, in the centre of which is a narrower belt of still lower pressure towards which the trade winds blow. The regions of low pressure are round the poles, the most remarkable being that round the S. pole. From the registers of 100,000 observations, it is shown that the mean pressure diminishes from 29·740 inches in lat. 45° to 50° S., to 28·960 inches in lat. 75° to 80° S. The low pressures are the result either of high temperature, or of an excessive amount of vapour in the atmosphere. Ascending currents of air prevail in all regions of low pressure, and pour over in the upper currents of the atmosphere into the regions of high pressure.

§ 4. **Currents of the Atmosphere.**—Besides the small horary undulations, there are vast waves moving over the oceans and continents in separate and independent systems, being confined to local yet very extensive districts, always accompanied with continued rains or dry weather over wide tracts of country. By numerous barometrical observations made simultaneously in both

hemispheres, the courses of several have been traced, some of which take 24, others 36 hours, to accomplish their rise and fall. One especially of these vast barometric waves, many hundreds of miles in breadth, has been traced over the greater part of Europe, and not its breadth only, but also the direction of its front and its velocity, have been clearly ascertained. The course of another wave has been made out from the Cape of Good Hope, through many intermediate stations, to the observatory at Toronto, in Canada. Since every undulation has its perfect effect independently of the others, each one is marked by a change in the barometer, and may be beautifully represented by curved lines on paper, constructed from a series of observations. The general form of the curve shows the character of the principal wave, while small undulations in its outline mark the maxima and minima of the minor oscillations. Although, like all other waves, these in the atmosphere are but waving forms, in which there is no transfer of air, yet winds arise from them; and Sir John Herschel was of opinion that the crossing of two of these vast aërial waves, coming in different directions, may generate at the point of intersection those tremendous revolving storms, or hurricanes, which spread desolation far and wide.

The air which expands and becomes lighter with heat, contracts and becomes heavier with cold, and, as there are 82 degrees of difference between the equatorial and polar temperature, the light warm air at the equator is constantly ascending to the upper regions of the atmosphere, and flowing N. and S. towards the poles, from whence the cold, dry, and consequently heavy air rushes to supply its place, since the same tendency to restore equilibrium exists in air as in water and other fluids. Now the winds from the poles blow in the upper regions of the atmosphere and, as they have no rotatory motion when they leave the poles, they are deflected from their meridianal course by the continually increasing velocity of the earth's rotation as they approach the equator. But these polar winds, being cold, dry, and heavy, sink down at the tropics and become surface winds; and as they still revolve slower than the corresponding parts of the earth at which they successively arrive, the bodies on its surface strike against them with the excess of their velocity, so that the wind, to a person who thinks himself at rest, blows in a direction contrary to that of the earth's rotation. For that reason a current from the N. becomes the N.E. trade wind after arriving at the tropic of Cancer, and one from the S. becomes the S.E. trade wind after leaving the tropic of Capricorn. These two winds continue their course, and when they arrive at the equator, being highly rarefied, they probably rise, cross each other, and then each pursues its course as an upper current till they come to the tropics; and

now being chilled in the higher regions, they sink down, cross again, and each flows along the surface to the poles, where there would be an accumulation of air if they did not cross and rise to the surface of the atmosphere to begin a new course.

It was shown that the easterly direction of the trade winds is caused by currents of air coming along the surface of the globe with less rotatory motion than the places they successively arrive at; on the contrary, the surface currents that flow from the tropics to the poles have a greater rotatory motion than the latitudes they successively come to; therefore they become a N.W. wind in the southern hemisphere, and a S.W. wind in the northern; which are the prevailing winds in the extra-tropical latitudes. In fact, the difference of temperature puts the air in motion, and the direction of the resulting wind at every place depends upon the difference between the rotatory motion of the wind and the rotatory motion of the earth; the whole theory of the *trade winds* depends upon these circumstances.

Thus, in each of the temperate, and in each of the torrid zones, there are two currents of wind, an upper and an under current, blowing contemporaneously in opposite directions. Wherever these currents cross there is a region of calms, because they balance or neutralise each other through a certain space and then go on. Hence there is a belt of calms a little N. of the equator, which girdles the earth with a mean breadth of 6 degrees: on each side of this are the trade winds, of which the N.E. trade wind is the narrowest, on account of the excess of land in the northern hemisphere: then come the calms of Cancer and Capricorn, or *Doldrums* of the sailors; then the extra-tropical winds; and lastly the polar calms.

That the winds cross one another in the calm belts there seems to be no doubt. For example, two winds proceed from the calm belt of Cancer that blow along the surface of the earth: one from its S. side in a steady breeze, which is the N.E. trade wind; another wind comes from the N. side of the same belt of calms, which blows to the N.E., and forms the S.W. winds so prevalent in the North Atlantic. They leave the calm belt loaded with vapour, which is precipitated as they pass into a colder zone, and they supply all the springs and rivers in the northern hemisphere with water. Now these S.W. winds do not obtain that enormous quantity of vapour while crossing the Atlantic, for they probably give by rain as much as they receive by evaporation, therefore it can only come from the southern hemisphere. The S.E. trade winds carry the moisture evaporated from the great southern ocean to the equator; there they rise into the higher regions of the atmosphere, and blow as an upper current to the calm belt of Cancer; and now, being chilled, they sink down and come out from the N. side of the

calm belt as the rainy S.W. winds of the extra-tropical northern hemisphere. The very same reasoning applies to the calm belt of Capricorn, the direction of the winds alone being different. Thus it has been considered that the winds in their circuits cross in the calm regions.

The polar calms where the winds cross are not points but spaces of considerable extent, the existence of which is proved both by observations and theory, for Parry and Barrow found reasons during their voyages in the Arctic Circle to believe that there is a perpetual calm at the N. pole; Bellot also records the existence of a calm region in the frigid zone; and Professor J. H. Coffin, by a laborious investigation of the winds of the northern hemisphere, has determined the region of N. Polar calms to be situated in 84° N. lat. and 105° W. long.; consequently the pole of the winds coincides with the pole of maximum cold determined by Sir David Brewster, for the pole of maximum cold is no more a point than the pole of the winds, but an area of some extent. The great currents of air, like the oceanic rivers, or great currents of the sea, both unite in tempering the excess of heat in the tropics, and of cold in the polar and temperate regions.

Rain-dust has been most wonderfully the means of proving that the trade winds after meeting at the equator rise up, cross, and continue their course as upper currents. A brick-red dust has frequently fallen in large quantities on ships in the Atlantic, especially about the Cape de Verd Islands, which was supposed to be brought by the winds from the deserts of Africa; but specimens of it having been examined by Professor Ehrenberg, from the Cape de Verd Islands, from Malta, Genoa, Lyons, and the Tyrol, he found that they all consisted of infusoria and organisms whose habitat is South America; and Captain Maury considers it 'as an established fact, that there is a perpetual upper current of air from South America to North Africa, and that the volume of air which flows to the northward in these upper currents is nearly equal to the volume which flows to the southward with the N.E. trade winds.' Clouds carried by an upper current are frequently seen flying in a contrary direction to those nearer to the earth, and it is a well known fact that the trade winds have a limited vertical extent of about three miles, and that at a certain elevation, on the top of the Peak of Teneriffe for example, the wind blows in an entirely contrary direction from that prevailing at the same time at the level of the sea.[1]

Near the equator the trade winds, N. and S. of it, so completely

[1] In the Atlantic the S.E. trade wind blows with most regularity between 10° and 5°, and with most force between 10° and 15° S. lat.

neutralise each other, that far at sea a candle burns without flickering. This zone of calms and light breezes, known as the *Variables,* is subject to heavy rains and violent thunderstorms. On account of the unequal distribution of land and water in the northern and southern hemispheres, the terrestrial equator is not the line of greatest heat, therefore the centre of the zone of equatorial calms in question does not coincide with it, but runs along the 6th parallel of N. lat.; however, it changes in position and extent with the declination of the sun. In summer it is found between the parallels 8° and 14° N. lat., and in spring it lies between 5° S. and 4° N. lat. In fact, the whole system, including the calm belts at the tropics, the trade winds, and the zone of equatorial calms, follows the sun's motion in declination, moving backwards and forwards annually 1000 m. in latitude, nearly. In mid-ocean in the Atlantic, the *north trades* prevail between latitudes 9° and 30°, and in the Pacific between latitudes 9° and 26°; and the *south trades* in the Atlantic, between latitudes 4° N. and 22° S., and in the Pacific between latitudes 4° N. and 23½ S. These limits are, however, not stationary, but follow the sun, advancing northwards from January to June, and retreating southwards from July to December.

The region of equatorial calms is a belt of about 4° or 5° in breadth, stretching across the Atlantic and the Pacific, generally parallel to the equator. It has a lower atmospheric pressure than the regions of the trades, and it is subject daily to heavy rains and thunderstorms. In the Indian Ocean this belt of calms wholly disappears during the S.W. monsoon.[1]

Thus, though the trade winds extend to the 28th degree on each side of the equator, their limits vary considerably in different parts of the ocean, moving to the N. or S., according to the position of the sun; and in the Atlantic the N.E. trade wind is less steady than the S.E. These perennial winds are known by recent observation to be less uniform in the Pacific than in the Atlantic; they only blow permanently over that portion between the Galapagos Archipelago, off the coast of America, and the Marquesas. In the Indian Ocean the S.E. trade wind blows from a few degrees E. of Madagascar to the coast of Australia, between 10° and 28° S. lat. The trade winds are only constant far from land, because the diminished atmospheric pressure from the heating effects of the sun on continents and islands combined with the rotation of the earth changes them into periodical monsoons, which are steady currents of air in the Arabian Gulf, the Indian Ocean, and the China Seas.

---

[1] Buchan's 'Handy Book of Meteorology.' 2nd Edition.

When the sun has crossed the equator, and his vertical rays fall on the extensive and arid plains of Asia, the great mass of superincumbent air, being highly rarefied, ascends, and winds from all neighbouring regions converge to this space by in-draught. But since the calms of Cancer do not extend to the Indian Ocean, the S.E. trade winds pass into the northern hemisphere ; and as they also are drawn into the vortex over the land to maintain the equilibrium, they are deflected from their course, and being at once acted upon by the in-draught to the heated plains and the rotation of the earth, they become S.W., S., S.E., and E. monsoons at different points on the coast of Asia. But as soon as the sun passes into the southern hemisphere the Asiatic plains become cool, and the S.E. trade winds resume their wonted course, and from October to April they become the S.E. monsoon, so that the S.E. trade wind in the Indian Ocean is alternately a trade wind and a monsoon.

The influence of these heated plains upon the winds is felt for 1000 m. and more at sea. Thus, though the Desert of Gobi and the sunburned plains of Asia are for the most part north of the latitude of 30°, their influence in producing monsoons is felt S. of the equator. In like manner the Central American monsoons of the Pacific are caused by the heated plains of Utah and Texas; those of the Mexican Gulf by the dry lands of New Mexico ; and the monsoons in the Gulf of Guinea by the sandy deserts of Africa. Thus the monsoons are not occasioned by the sun's action on the sea, but by his action on the land ; and it is to the N. of the N.E. trade winds that most of these deserts lie.[1] Similarly also, the heated interior of Australia causes an in-draught of air during the time that the sun is S. of the equator, and a N.W. monsoon caused by the reversal of the S.E. trades, brings rain to all the northern coast of that island-continent.

The Society and Sandwich Islands, that are far removed from any large extent of land, have a very singular but marked effect upon the wind. They interfere with the trades very often, and turn them back, for westerly and equatorial winds are common at both these groups, but they are local and of little extent.

The changes of the monsoons are accompanied by heavy rain and violent storms of thunder and lightning. The ascent of the warm air between the tropics occasions a depression of the barometer amounting to the tenth of an inch, which is a measure of the force producing the trade winds.[2] In both hemispheres there is a regular

---

1 'Physical Geography of the Sea' (Maury).

2 Sir John Herschel observed that, on account of the upper flow of heated air not being immediately compensated by polar currents, the barometer is two tenths of an inch higher at the tropics than at the equator.

variation in the mean height of the barometer within the zone in which these great aërial currents flow; it is higher at their polar limits, and decreases with extreme uniformity towards their equatorial boundaries, the difference in both hemispheres being 0·55 of an inch.

The unequal temperature of the land and sea causes *Sea Breezes* which blow towards the land during the day, and *Land Breezes* which blow seaward in the night: the former are by much the strongest, for the difference of the temperature of the air over the land and over the sea is greater during the day than in the night; they are not perceptible in the mornings and evenings, because the temperature of the land and water is then nearly the same. In the early morning the sea is calm and the wind at rest; but when the sun has warmed the land it rarefies the air above it, which ascends, and cool air from the ocean comes to supply its place. At first it appears far off as a fitful dark line upon the glassy sea; then it comes in a gentle ripple, which by degrees freshens into a brisk breeze, changing the molten surface into the deepest azure. At sunset the land begins to radiate its heat into space; by degrees the breeze dies away, till the air over the earth becomes cooler and heavier than that over the sea, and a land wind rises which lasts till morning. It is impossible to describe how grateful these breezes are in a tropical country—drooping nature revives under their benign influence.

The trade winds and monsoons are permanent, depending on the motion of the sun; but it is evident from theory that there must be partial winds in all parts of the earth, occasioned by the local circumstances that affect the temperature of the air. Consequently the atmosphere is divided into districts, both over the sea and land, in which the winds have nearly the same vicissitudes from year to year. The regularity is greatest towards the tropics, where the causes of disturbance are fewer. In the higher latitudes it is more difficult to discover any regularity on account of the greater proportion of land, the difference in its radiating power, and the greater extremes of heat and cold; besides, on account of the form of the earth, the extra-tropical surface winds come into areas vastly less than those they have left, consequently they are compressed or heaped up, which makes them more ready to come into conflict with those winds that may be raised by local causes. But even in these latitudes a degree of uniformity prevails in the succession of the winds; for example, in all places where N. and S. winds blow alternately, a vane veers through every point of the compass in the

Ermason, by careful observations in the Pacific and Atlantic Oceans, makes this difference only 0·15 of an inch, which is that stated in the text.

transition, and in some places the wind makes several of these gyrations in the course of the year.[1] The S.W. winds so prevalent in the Atlantic Ocean between 30° and 60° N. lat. are produced by the under currents going N. from the calm belt of Cancer, and as it has a greater rotatory motion than the earth in these latitudes, it produces a S.W. wind. On this account the average voyage from Liverpool to New York in a sailing vessel is 40 days, while it is only 23 days from New York to Liverpool. For the same reason the average direction of the wind in England, France, Germany, Denmark, Sweden, and North America, is some point between S. and W. N.W. winds prevail in the corresponding latitudes of the southern hemisphere from the same cause. In fact, whenever the air has a greater velocity of rotation than the surface of the earth, a wind more or less westerly is produced; and when it has less velocity of rotation than the earth, a wind having an easterly tendency results. Thus there is a perpetual change between the different masses of the atmosphere, the warm air tempering the cold of the higher latitudes, and the cold air mitigating the heat of the lower; it will be shown afterwards that the aërial currents are the bearers of elements on which the life of the animal and vegetable world depends.

A rapid fall in the barometer is an invariable sign of an approaching gale; so certain, that no ship, much less a coasting vessel on our dangerous coasts, ought to be without one, either to give warning not to sail, or to seek immediate shelter if at sea. This simple and cheap instrument might have saved hundreds who have annually perished in the British seas. A sudden and great fall in the mercury is also a fearful presage of a revolving tempest or hurricane.

§ 5. **Hurricanes.**—Hurricanes are those storms of wind in

---

[1] In the northern hemisphere a north wind sets out with a less rotatory motion than the places have at which it successively arrives, consequently it veers through all the points of the compass from N. to N.E. and E. If a S. wind should now spring up, it would gradually veer from S. to S.W. and W., because its rotatory velocity would be greater than that of the places it successively comes to. The combination of the two would cause a vane to veer from E. to S.E. and S.; but the rotation of the earth would now cause the south wind to veer round from S. to S.W. and W.; and should a north wind now rise, its combination with the west wind would bring the vane round from W. to N.W. and N. again. At the Greenwich Observatory the wind makes five gyrations in that direction in the course of a year. In Europe it is the contention of the N.E. and S.W. winds which causes the rotation of the wind and the principal changes of weather, the S.W. being warm and moist, the N.E. cold and dry, except where it comes over the North Sea.

which the portion of the atmosphere that forms them revolves in a horizontal circuit round a vertical or somewhat inclined axis of rotation, while the axis itself, and consequently the whole storm, is carried forwards along the surface of the globe, so that the direction in which the storm is advancing is quite different from the direction in which the rotatory current may be blowing at any point; the progressive motion may continue for days, while the wind accomplishes many gyrations through all the points of the compass in the same time. In the Atlantic the principal region of hurricanes is to the E. of the West India Islands, and in the Indian Ocean to the E. of the Island of Madagascar: consequently the former is in the northern hemisphere, the latter in the southern; but in most cases the storm moves in an elliptical or parabolic curve. The West Indian hurricanes generally have their origin eastward of the Lesser Antilles or Caribbean Islands, and the western vortex of their path near the tropic of Cancer, or about the exterior limit of the N.E. trade wind. The motion of the storm, before it reaches the tropic, is nearly in a straight line from S.E. to N.W., and after it has passed the tropic from S.W. to N.E. the convexity of the curve is turned towards Florida and the Carolinas. In the South Pacific Ocean the body of the storm moves in an exactly opposite direction. The hurricanes which originate S. of the equator, and whose initial path is from N.E. to S.W., turn near the tropic of Capricorn, and then trend from N.W. to S.E., so that the convexity of the curve is turned towards Madagascar.

The West Indian hurricanes occur most frequently from July to October. *Typhoons* on the coasts of Hindostan happen from May to October, most often in July, August, and September. In the South Indian Ocean they fall between November and May during the N.W. monsoon in the Indian Archipelago.

In the Atlantic these dreadful storms are caused by the irregularity in the temperature of the Gulf Stream and of the neighbouring regions, both of air and water. A difference of 48° Fahr. has been observed between the temperature of that stream and the air on each side of it, whence Captain Maury concludes that 'the excess of heat daily brought into such a region by the waters of the Gulf Stream would, if suddenly stricken from them, be sufficient to make the column of the superincumbent atmosphere hotter than melted iron. With such an element of atmospherical disturbance in its bosom, we might expect storms of the most violent kind to accompany it in its course. Accordingly, the most terrific that rage in the ocean have been known to spend their fury within or near its borders.'

The extent and velocity of the Atlantic hurricanes are very great; the most rapid move at the rate of 45 m. an hour. The hurricane

which took place on August 12, 1830, was traced from the eastward of the Caribbean Islands to the banks of Newfoundland, a distance of more than 3000 m., which it passed over in 6 days. Although that of September 1, 1821, was not so extensive, its velocity was greater, as it moved at the rate of 30 m. an hour. The Bahama hurricane of October 1866 moved at the speed of 30 m. an hour, when it was nearing Bermuda; but the violence and destructiveness of the hurricane depend not on the velocity with which the whole storm moves, but on the speed with which the winds whirl round and in upon the centre. In the Bahama hurricane this was at the rate of 80 to 100 m. an hour, and for short intervals even 120 to 130 m. an hour, a velocity like that which was registered during the Guadaloupe hurricane of September 1865. Small storms are generally more rapid than those of great magnitude. Sometimes they appear to be stationary, sometimes they stop and again proceed on their course, like water spouts. Hurricanes are often contemporaneous, and occur near to one another. This happened in the China Seas in October 1840, when the two storms met at an angle of 47°, and it was supposed that the ship 'Golconda' foundered in that spot with 300 people on board. A hurricane has been split or divided by a mountain into two separate storms, each of which continued its new course, and the gyrations were made with increased violence. This occurred in the gale of December 25, 1821, in the Mediterranean, when the Spanish mountains and the maritime Alps became new centres of motion.

The whirling motion of these fearful storms begins in the higher regions of the atmosphere before it is felt on the earth. During their course there is a continual intermixture of the lower and warmer strata of air with those that are higher and colder, producing torrents of rain, and sometimes violent electric explosions.

The rotation as well as the course of the storm is in a different direction in the two hemispheres, though always alike in the same. In the northern the gyratory movement of the wind is from E., through the N., to W., S., and E. again; while in the southern hemisphere the rotation about the axis of the storm is in the contrary direction. Hurricanes happen S. of the equator between December and April; in the West Indies between June and October. Rotatory storms frequently occur in the Indian Ocean, and the typhoons of the China Seas are real hurricanes of great violence. Both conform to the laws of such winds in the northern hemisphere. The Atlantic storms occasionally reach Spain, Portugal, and the coast of Ireland. Tremendous storms often pass over Great Britain, and lesser ones often occur between the Chops of the Channel and Madeira. A great hurricane passed over Ireland and the west coast

of England in January 1839. A strong gale had blown from S.S.E. on the 6th, when about 10 in the evening the air became calm and warm, which was evidently during the passage of the axis of the storm, for soon after the gale was renewed with the utmost violence, but now it was from the S.W. and W.S.W., and on the evening of the 7th was accompanied by snow, thunder, lightning, and intense cold. At Leeds, 70 m. distant from the Irish Sea, and separated from it by a ridge of hills, there was everywhere a saline deposit.

Modern investigations have shown that the storms of Europe and North America move from W. to E., or from S.W. to N.E., and that the winds circle round the area of least pressure, with a constant tendency to turn inwards towards that area.

The *temperature* of winds depends upon the nature of the surface over which they blow. In Europe the coldest and driest wind is from the N. and N.N.E.; in America it is from the N. and N.N.W., because both come from the polar ice, and sweep over extensive tracts of land. The warm and moist winds in Europe are from the S.W., because they blow over a great extent of ocean, especially on the western side of the continent. The Puna winds, which blow on the barren table-land of Puna to the E. of Arequipa, in Peru, are cold dry winds which, having crossed the Cordilleras, have become parched to an extent which has no equal anywhere in the world. When a mule dies in crossing these plains it is dried to a mummy in a few days. In this district the ancient inhabitants of Peru preserved their dead; and travellers have to protect their faces from the glare and heat of the day, and the intense cold of the night.

The revolving motion accounts for the sudden and violent changes observed during hurricanes. In consequence of the rotation of the air, the wind blows in opposite directions on each side of the axis of the storm; and the violence of the blast increases from the circumference towards the centre of gyration, but in the centre itself the air is in repose: hence, when the body of the storm passes over a place, the wind begins to blow moderately, and increases to a hurricane as the centre of the whirlwind approaches; then in a moment a dead and awful calm succeeds, suddenly followed by a renewal of the storm in all its violence, but now blowing in a direction diametrically opposite to what it had before. This happened in the Island of St. Thomas on August 2, 1837, where the hurricane increased in violence till half past seven in the morning, when perfect stillness took place for 40 minutes, after which the storm recommenced in a contrary direction. The breadth of a hurricane is greatly augmented when its path changes its direction in crossing the tropic. In the Atlantic the vortex of one of these

tempests has covered an area from 600 to 1000 m. in diameter. The diameter of the storm in the Southern Indian Ocean is generally from 1000 to 1500 m.; and the general rate of motion is from 4 to 7 m. an hour. The breadth of the lull in the centre varies from 5 to 30 m.; the height is from 1 to 5 m. at most: so that a person might see the strife of the elements from the top of a mountain such as Teneriffe or Mauna Loa, in a perfect calm, for the upper clouds are frequently seen to be at rest during the hideous turmoil in the lower regions. When the centre of the Bahama hurricane of 1866 passed over Nassau, the calm lasted an hour and a half, from 7.20 to 8.50 P.M. At 7.30 the clouds in the zenith which before had appeared to be revolving rapidly rose, and the stars appeared, while banks of clouds remained all round the horizon in heavy dense masses. The calm covered an area of 23 m. across.

The sudden fall of the mercury in the barometer in latitudes habitually visited by hurricanes is a certain indication of a coming tempest. The air becomes rarefied; and as the atmosphere is disturbed to some distance beyond the actual circle of gyration, or the limits of the storm, the barometer often sinks some hours before its arrival: it continues sinking in the first half of the hurricane, and again rises during the passage of the latter half, though it does not attain its greatest height till the storm is over. During the West Indian hurricane of October 1, 1866, while the storm was passing the barometer fell 0·7 inch in an hour; and during the hurricane which devastated Guadaloupe, September 6, 1866, at Marie Galante the barometer is said to have fallen 1·693 inch in an hour. The diminution of atmospheric pressure extends over a wider area in the temperate zones than in the torrid.

As the fall of the barometer gives warning of the approach of a hurricane, so the laws of a storm's motion afford to the seaman knowledge to avoid it. In the northern temperate zone, if the gale begin from the S.E. and veer by S. to W., the ship should steer to the S.E.; but if the gale begin from the N.E., and change through N. to N.W., the vessel ought to go to the N.W. In the northern part of the torrid zone, if the storm begin from the N.E. and veer through E. to S.E., the ship should steer to the N.E.; but if it begin from the N.W. and veer by W. to S.W., the ship should steer to the S.W., because she is on the south western side of the storm. Since the laws of storms are reversed in the southern hemisphere, the rules for steering vessels are necessarily reversed also.[1]

---

[1] In all hurricanes hitherto observed, the sinking of the mercury, and the increase of the wind, have been more or less regularly progressive till

A heavy swell or storm wave is peculiarly characteristic of these tempests. In the centre of the hurricane the pressure of the atmosphere is so much diminished by rotation that the mercury in the barometer falls from one to two, and even two and a half inches. On that account the pressure of the ocean beyond the range of the wind raises the water in the centre of the vortex about two feet above its usual level, and proportionally to the degree of diminished pressure over the whole area of the storm. This mass of water, or storm wave, is driven bodily along with or before the tempest, and rolls in upon the land like a huge wall of water. It is similar to the earthquake wave, and is by no means the heaping up of the water after a long gale. Ships have been swept by it out of docks and rivers, and it has sometimes carried vessels over reefs and banks so as to land them high and dry: this happened to two ships on the coast of the Eastern Andaman Islands in 1844. Coringa, on the Coromandel coast, is particularly subject to inundations from that cause. In 1789 the town and 20,000 inhabitants were destroyed by a succession of these great waves during a hurricane, and as many perished there in 1839. On October 5, 1864, a great storm passed over Calcutta, and the storm wave which accompanied it, rising 10 ft. above the highest spring tides, laid the level country at the mouth of the Ganges under water, and caused the destruction of 45,000 persons. On October 31, 1876, one of the most destructive cyclones on record visited Lower Bengal, and in the districts of Chittagong, Noakholly, and Backingunge, destroyed

---

within three or four hours' sail of the centre of the storm; and in one class they have continued so even to the centre; while in another class, and by far the most terrible, the depression of the mercury has been sudden and excessive when within that distance of the centre, and the violence of the tempest far beyond the average. When a ship is within 50 or 60 miles of the centre, the storm has the mastery, and seamanship is of little avail. Rules for avoiding this calamity, and for managing a ship when involved in a hurricane, are fully explained in the 'Hurricane Guide' by William Radcliff Birt, published under the sanction of the Admiralty, in 12mo. London, 1850; and in the 'Sailors' Horn-Book for the Laws of Storms,' by H. Piddington, Esq., President of the Marine Courts of Inquiry at Calcutta.

Professor Dove has proposed a very ingenious explanation of the origin of rotatory storms by lateral currents in the upper atmosphere, produced by the overflow occasioned by ascending currents over highly heated districts (See Report of R. S. to Gov. on Meteorological Observations); whilst Mr. Birt has united in a very abridged and useful form the practical information collected by the authors who preceded his little essay on Hurricanes. Of late years this subject has occupied much attention in India and the United States, as well as in European countries.

upwards of 215,000 souls. There were no signs of danger up to eleven o'clock on the night of the catastrophe, but before midnight the storm wave had swept over the islands of Dakhin, Shahabbazpur, Hattiah, and Sundeep, to a depth in places of 20 ft. It also extended some 5 or 6 m. inland.

Besides storm waves, storm currents are raised, which revolve with the rotation of the wind, and are of the greatest force near the centre of the vortex. The rise of the sea, by the pressure of the surrounding ocean and the irresistible fury of the wind, makes a tremendous commotion in the centre of the storm, where the sea rises, not in waves, but in pyramidal masses. The noise during its passage resembles the deafening roar of the most tremendous thunder; and in the *Typhoons* in the China seas it is like numberless voices raised to the utmost pitch of screaming. In general there is very little thunder and lightning; sometimes a vivid flash occurs during the passage of the centre, or at the beginning of the storm; yet in Barbadoes the whole atmosphere has been enveloped in an electric cloud.

A thick lurid appearance, with dense masses of cloud in the horizon, ominous and terrible, are the harbingers of the coming tempest. The sun and clouds frequently assume a fiery redness, the whole sky takes a wild and threatening aspect, and the wind rises and falls with a moaning sound, like that heard in old houses on a winter's night. It is akin to the 'calling of the sea,' a melancholy noise which, in a dead calm, presages a storm on some parts of the English coast.

Those intensely violent gales, of short duration, called *Arched Squalls*, because they rise from an arch of clouds on the horizon, are not rotatory: they occur in the Strait of Malacca, attended by fierce thunder and lightning and a lurid phosphorescent gleam. The N.W. gales in the Bay of Bengal, the *Tornadoes* on the African coast and the *Pamperos* of the Rio de la Plata, are of the same nature. The *Pampero* blows in summer from the Andes across the pampas of Buenos Ayres to the sea coast. It is a dry wind, bringing clouds of dust and drying up the vegetation of the pampas. On an average a strong gale moves at the rate of 40 m. an hour,[1] a storm at about 59, and hurricanes at 90.[2] Deserts, especially those of Africa and Asia, are subject to intensely hot winds of short duration, frequently fatal to exhausted travellers:

---

[1] The average rate of motion of European storms is about 18 m. an hour; sometimes the rate is only 15 m. an hour, whilst on rare occasions it is as great as 45 m.—Buchan's 'Meteorology.'

[2] A plan of conveying warnings of approaching storms was invented by the late Admiral FitzRoy, and was in operation for some time.

of these the *Simoom* and *Sand Wind* are the most formidable. A red lurid appearance in the atmosphere, caused by the quantity of burning sand raised by the wind, gives warning of their approach; everything is scorched in their passage, and breathing becomes painful. It is probably owing to the sand wafted by them, and to their parching dryness, that these winds are so deleterious, and not only to their temperature, since air heated to a much higher degree may be breathed with impunity, as was proved by Sir Joseph Banks and by Sir Francis Chantrey, in an atmosphere raised to more than 300° Fahr. The simoom generally blows from 6 to 24 hours, but sometimes it continues for 2 or 3 days, when it comes in gusts driving clouds of sand; nothing can withstand it. There can be no doubt that sudden changes of temperature occasion these formidable winds.

Hot winds from Africa blow in all the neighbouring countries; but receive important modifications from the nature of the country over which they pass. The hot moist *Sirocco* blows in Sicily, South Italy, Turkey (where it is called the *Samiel*, on account of its reputed poisonous nature), and even to the shores of the Black and Caspian Seas and the Steppes beyond the Volga. The Spanish *Solano* is hot and loaded with fine dust, and the *Harmattan* of Guinea and Senegambia, under the influence of which no dew falls, withers up vegetation between December and February. The low atmospheric pressure to the S. and the high pressure in the interior of North America during winter combine to cause the dry, cold, and violent winds called 'Northers,' which prevail from September to March in the Gulf of Mexico. The violence of the winds in the S. of Europe—the result of the differences in temperature of the Alps, the Mediterranean, and Africa—is notorious. The cold, tempestuous *Bora*, which sweeps from the Julian Alps over the Adriatic, and the violent *Mistral*, which blows from France down on the Gulf of Lyons, are two of these winds.

Whirlwinds are frequent in tropical countries, especially in deserts; sometimes several are seen at one time in the Arabian deserts, of all sizes, from a few feet to some hundred yards in diameter. They occur in all kinds of weather, by night as well as by day, and come without the smallest notice, rooting up trees, overwhelming caravans, and throwing down houses; and as they produce waterspouts when they reach the sea, they dismantle and even sink ships. Pillars of sand are often raised by them on the African deserts two or three hundred feet high. In Nubia, Bruce saw eleven advancing towards him with considerable swiftness. It was vain to think of flying where the speed of the swiftest horse could have been of no avail, and that conviction riveted him on the spot. They retreated, leaving him in a state of mind

between fear and astonishment, to which he could give no name. Whirlwinds advance with a loud rushing noise, and are frequently attended by electrical explosions. At the close of the storm a fall of rain generally takes place. Dust whirlwinds prevail in India and Nubia. Sir S. Baker describes those of Nubia in April, May, and June :—'I have frequently seen many such columns at the same time in the boundless desert, all travelling or waltzing in various directions, at the fitful choice of each whirlwind: this vagrancy of character is an undoubted proof to the Arab mind of their independent and diabolical nature.' The waterspouts so frequently seen on the ocean originate in adjacent strata of air of different temperatures, running in opposite directions in the upper regions of the atmosphere. They condense the vapour, and give it a whirling motion, so that it descends tapering to the sea below, and causes the spray of the agitated water to ascend in a pointed spiral till it joins that from above, and then it looks like two inverted cones, being thinner in the middle than either above or below. When fully formed they appear as tall pillars stretching from the sea upwards to the clouds, and exhibiting the same whirling round their axis, and the same progressive movement of the mass as in dust whirlwinds. When a waterspout has a progressive motion, the upper and under part must move in the same direction, and with equal velocity; otherwise it breaks, which frequently happens.

CHAPTER XXIV.

ATMOSPHERIC PHENOMENA—*continued.*

§ 1. **Evaporation.**—Moisture is evaporated in an invisible form from every part of the land and water, and at all temperatures, even from snow. Dr. Darwin mentions that the snow once entirely disappeared from the Nevado of Aconcagua, in Chile, from evaporation under a cloudless sky and an excessively dry air. The vapour rises and mixes with the atmosphere; and as its pressure and density diminish with the height above the surface of the earth, in consequence of gravitation, there is absolutely less moisture in the higher than in the lower regions of the air.[1]

[1] The humidity of the air is measured by the *Hygrometer*, an instrument which shows the rapidity of evaporation at all temperatures; for the

The trade winds promote evaporation, for as soon as the vapour is formed they carry it off, otherwise the atmosphere would become saturated, and no more would rise. From the surface of the whole globe it has been computed that 186,240 cubic m. of water is annually raised in the form of vapour, and annually descends in rain, hail, and snow. The air is the storehouse, the winds the swift messengers who carry it to water the land and feed the rivers. The power of the sun and air to raise and carry this immense mass must be enormous. It is on the same stupendous scale in which all the mighty operations of nature are conducted.

There are about 25 millions of sq. m. of sea in the northern hemisphere, and nearly 75 in the southern; besides, the zone of the S.E. trade winds is much greater than the northern, and covers three times as much water: yet the mean annual amount of *rain* in the northern hemisphere is probably about 37 inches, and 26 in the southern; for the vapour from the great reservoirs at the equator and the southern hemisphere is wafted by the S.E. trade wind in the upper regions of the atmosphere till it comes to the calms of Cancer, where it sinks down and becomes a S. and S.W. surface wind, and then the condensation begins that feeds all the greatest rivers in the world. The atmosphere is much more unstable in the northern hemisphere with its excess of land, than in the southern with its excess of water. Rains, fogs, thunder, calms, and storms, all occur much more frequently, and are much more irregular also as to time and place, on this side than they are on the other side of the equator. The evaporation is greatest between the tropics, from the excess of heat and the preponderance of the ocean, and its average quantity decreases from thence to the Poles. Over the open sea, in all latitudes, the air contains a larger proportion of moisture than in the interior of the continents; the evaporation diminishing from the coasts to the interior of the latter: so that in the interior of the United States of North America, in the deserts of Asia, and in the interior of Australia, the aqueous vapour contained in the air is very small. There is scarcely any evaporation in the deserts of Africa, and the extreme

---

rate of evaporation is in proportion to the dryness of the atmosphere, and is nearly in the inverse ratio of the density. When the evaporation is below 30° on the scale of the hygrometer the air is very dry, when above 80° it is intensely damp. The most accurate mode of determining the quantity of moisture in the air is by the *wet-bulb thermometer*, which shows the temperature of evaporation; hence the temperature at which the atmosphere is saturated with humidity is easily found in the tables. Daniel's Hygrometer and August's Psychrometer are to a certain degree founded on this principle.

heat, increased by the highly heated sand, opposes aqueous precipitations; and as the winds which blow over it increase in temperature and so become drier, this land is doomed to perpetual sterility. The air over the steppes of Siberia is likewise nearly devoid of moisture. A very great degree of dryness was observed by M. Ermann between the valleys of the Irtish and Ob, after a continued S.W. wind with a temperature of 74°·7 Fahr.

Throughout all the countries in the northern hemisphere where observations have been made on the variations of atmospheric moisture, it appears that the air contains absolutely less vapour in January than in any other month of the year, yet at that time there is the greatest dampness to our sensations; while in July the air feels driest, although, on account of the heat, evaporation is the greatest. In summer the dew point is much further below the temperature of the air than in winter, hence the air is drier. If the temperature of air containing a certain amount of vapour is raised, its relative humidity becomes less, and to the sensation it is drier. The proportion of vapour in the air varies generally with the direction of the wind: in Europe it is greatest in a S.W. wind, and least in a N.E. and N.W.; the former, being part of the equatorial current drawn down to the surface of the globe, comes warm and moist over the Atlantic, while the northern wind blows dry and cold from the pole. The moisture in the atmosphere obstructs the free passage of the heat resulting both from solar and from terrestrial radiation. This is one of the most important of the purposes served by the moisture in the atmosphere. If the air contained no moisture, the radiation from the earth's surface during the night would be so rapid and excessive that all living things would be destroyed. Mountainous countries where, owing to the elevation, there is a comparatively small amount of aqueous vapour in the atmosphere, feel the effects of comparatively unobstructed radiation. The traveller over snow fields is scorched by the blaze of the sun. In polar regions also the intense heat of the sun's rays is the result of the want of vapour in the atmosphere. When the moisture is abundant and the tension great, which is often the case before rain, the air is very transparent, and distant objects appear nearer, and all their details are more distinctly seen: from this circumstance the clearer view of distant mountains and headlands indicates wet weather. Very dry air is also exceedingly transparent, as on the tops of very lofty mountains, and in sandy deserts, where the stars are seen to shine with uncommon lustre, and the brighter planets are visible in the daytime. On account of the heat the air between the tropics contains more moisture than elsewhere; and were it not for the amount of evaporation

the warmth there would be greater than it is, for a depression of temperature takes place during evaporation by the absorption of the heat, which thus becomes insensible to the feelings and to the thermometer. The evaporation and consequent absorption of heat may be so rapid as to produce intense cold; upon this principle the speedy evaporation of ether or chloroform by means of a current of air will freeze water upon the outside of the vessel in which either of these volatile liquids is contained.

The quantity of atmospheric moisture varies also with the hours of the day and night. In early morning the evaporation accumulates near the surface of the ground from the resistance of the air above it to its free diffusion, but as the sun rises above the horizon and warms the earth the air becomes rarefied and ascends, carrying the vapour with it; so that the quantity near the ground is diminished till evening, when, on account of the lowness of the temperature, the ascending currents cease and the air becomes loaded with vapour and deposits its excess in the shape of dew or hoar frost. For in the night the earth radiates part of the heat it received during the day through the atmosphere into space, and the temperature of the bodies on its surface sinks below that of the air, and by abstracting part of the heat which holds the humidity of the air in solution a deposition takes place. The *dew point* is the temperature at which vapour is deposited on bodies colder than itself, but before any deposition takes place the air must be saturated with moisture at the temperature of the body upon which the dew is deposited. It is very abundant on the shores of continents, but it is not deposited on small islands in the midst of large seas, because on them the difference between the temperature of the day and the night is not sufficiently great. Dalton estimated that the quantity of dew that falls in England annually would form a bed of water uniformly spread over the whole kingdom of five inches in depth. If the temperature fall to or below 32°, the dew is frozen and becomes *hoar frost*, which is the ice of dew. Clouds and winds are unfavourable for the formation of dew; the former by preventing the free radiation of heat into space, and the latter by constantly renewing the air in contact with the ground, and thus preventing the temperature from falling sufficiently low. Actual contact is necessary for its formation, as it is never suspended in the air like fog. Dew falls in calm serene nights, but not on all substances indifferently; it wets them in proportion to their powers of radiation, leaving those dry that radiate feebly or not at all. Dew is most abundant on coasts; in the interior of continents there is very little, except near lakes or rivers. When dew is congealed into hoar frost it forms beautiful crystals, and the cold which

produces it is very hurtful to vegetation, but the slightest covering preserves plants from its effects.

When the atmosphere is so saturated with the vapour of water that it is precipitated in the air itself, *a fog* is the result, which is supposed to consist of small globular particles of water. When dew is formed, the earth is colder than the air in contact with it; but the case is exactly the contrary when fogs take place, the moist soil being warmer than the air. In countries where the soil is moist and warm, and the air damp and cold, thick and frequent fogs arise, as in England, where the coasts are washed by a sea of elevated temperature from the Gulf Stream, and the excess of the heat of the Gulf Stream above the cold moist air is the cause of the perpetual fogs in Newfoundland, and on the approach of winter those dense fogs, known to seamen as frost smoke, steam from the Polar Ocean till it is frozen over. Fogs rarely occur at sea between the parallels of 30° N. and S. lat., that is, over nearly half the globe. For one fog within these limits in the Atlantic, no less than 83 take place on the polar side; and although these fogless regions are occasionally subject to hurricanes, a gale of wind is very rare.[1]

§ 2. **Clouds.**—Superior to all these phenomena, and at a considerable height above the earth, the air is very dry, because under ordinary circumstances the vapour ascends in a highly elastic and invisible state till it reaches a stratum of air of lower temperature, and then it is condensed into clouds. The *region of clouds* is a zone at a height varying from 1300 to 21,320 ft. (according to Kämtz's measurements) above the surface of the earth. Balloon ascents have, however, found that this height is much too small. Gay-Lussac, when at a height of 23,000 ft., saw clouds floating apparently at a great height above him, and Mr. Glaisher has made the same observation. It is probable that the cirrus clouds are often 10 m. above the earth. From friction and other causes the currents of air in the lower parts of that zone run horizontally on each other, often in different and frequently in opposite directions; and as they generally differ in moisture, temperature, and velocity, the colder condense the invisible vapour in the warmer and make it apparent in the form of a cloud, which differs in no respect from a fog, except that one floats high in the air, while the other rests on the ground. When a heavy and dry wind begins to set in or take the place of a moist or light wind, it generally does so by edging itself beneath the moist wind and forcing it

---

[1] In the North Atlantic the foggy and stormy latitudes are between 45° and 60° N., and in the South Atlantic the most foggy region is between 50° and 60° S. lat., the most stormy between 50° and 55°.—Captain Maury.

wedgeways into the upper regions of the atmosphere, where condensation rapidly follows, and dense black clouds, often heavily charged with rain, are formed. In Britain the heavy E. or polar current thrusts high up into the air the rain-bringing S.W. wind, causing it to darken the sky and pour down torrents of rain.[1]

In the balloon ascents at Kew it was observed that the cloud region there is from 2000 to 6500 ft. above the surface of the earth, that its thickness varies from 2000 to 3000 ft., and that the temperature at the top is the same with that at the bottom of the stratum. The cloud region of the trade winds is from 3000 to 5000 ft. high, and it is generally higher over the sea than over the land for the same amount of vapour in the wind. In the N. temperate zone the cloud region is high over the land and low over the water; and, as a rule, the farther inland the drier the air and the higher the cloud region.

At moderate heights clouds consist of vapour; but at great elevations, where the cold is severe, they are an assemblage of minute crystals of ice. The particles of which clouds are composed undergo constant renewal or change. As Espy has said, every cloud is either a forming or a dissolving cloud. When it is connected with an ascending current it increases in size, is dense at the top, and well defined in its outlines; but when the ascending current ceases and the particles begin to fall through the air by their weight, the cloud diminishes in size and density. Clouds near the earth take the contour of the land over which they are formed. Above the lower stratum of clouds there is frequently a clear space of air, above which are more clouds, then another clear space, and so on in succession. The appearance of the clouds, as seen in balloon ascents, is often very gorgeous.

Clouds assume three primary characters, from whence four subordinate forms are derived. The *cirrus*, or cat's-tail of sailors, is the highest; it sometimes resembles a white brush, at other times it consists of horizontal bands of slender silvery filaments. It is probable that they consist of minute spicules of ice or flakes of snow. The cirri for the most part arrange themselves in parallel bands which, by the effects of perspective, converge to opposite points in the horizon, and as they travel in their longitudinal direction they appear to be stationary. In the middle and higher latitudes of the northern hemisphere they often trend from S.W. to N.E. In Scotland they have been observed to advance from S.W. to N.W. towards N.E. to S.E. It is supposed that their parallel form arises from their being conductors between two foci

---

1 Buchan's 'Meteorology.'

of electricity, but, whatever the cause of this arrangement may be, it is very general; they are supposed by Humboldt and Arago to be connected with the phenomena of the aurora. Among these clouds, which occasionally appear like fleecy cotton or wool, halos and parhelia are formed which often precede a change of weather announcing rain in summer, in winter frost and snow.

Cumuli or summer clouds are rounded forms, resembling mountains covered with snow. They are formed by ascending currents of warm air which rise from the heated ground, and they are the clouds of day. They are of dense structure, are formed in the lower regions of the atmosphere, and are carried along in the current next the earth; sometimes they rise and cover the whole sky, and in the evening they frequently become more numerous and of deeper tint, passing into denser forms which presage storm or rain.

The *stratus* is the third of the primary characters of clouds: it is a horizontal band, which forms at sunset and vanishes at sunrise; it is, therefore, the cloud of night; it includes all the mists which are found in the evenings in valleys and over low lying grounds, and is the lowest of all the clouds. The subordinate varieties of clouds are combinations of these three principal classes.[1] The winds, the great agents in all atmospheric changes, carry the vapour to a distance where it is often condensed on the tops of the mountains into clouds which seem to be stationary, but in reality they are only maintained by a constant condensation of fresh vapour, which is carried off as soon as formed, by the wind, and becomes invisible on entering warmer air.

The rate at which clouds move is greater than is commonly supposed, exceeding considerably that of the wind at the surface of the earth. In May 1867 when the rate of the wind was about 42 m. an hour, clouds were observed near Edinburgh, which, though moving with apparent slowness, were really travelling at the rate of 72 m. an hour; and at another part of the same day, when the force of the wind was greater, the clouds moved at the rate of 109 m. an hour.

---

1 The four subordinate forms of clouds are the *cirro-stratus*, composed of little bands of filaments, more compact than the cirrus, forming horizontal strata, which seem to be numerous thin clouds when in the zenith, and at the horizon a long narrow band. The *cumulo-stratus* consists of the summer cloud, like snowy mountains heaped on one another, which at sunrise have a black or bluish tint at the horizon, and pass into the *nimbus* or rain cloud, which has a uniform grey tint, fringed at the edges—it often becomes a thunder cloud; and the fourth is the *cirro-cumulus*, a combination of filaments and heaped-up cumuli or summer clouds.

§ 3. **Rain.**—If, when two masses of air of different temperatures meet and mix together the temperature falls below the point of saturation, the particles coalesce and form drops of water, which fall in the shape of *rain* by their gravitation. And when two strata of different temperatures moving rapidly in contrary directions come into contact, a heavy fall of rain takes place; and as the quantity of aqueous vapour is most abundant in tropical regions, the drops are larger and the rain heavier there than elsewhere.[1]

The fall of rain, especially in low latitudes, depends upon the zone of trade winds and calms. In the region of the trade winds the sky is either mottled or serene, and the weather steady and delightful. These winds are the collectors and carriers of the vapour which the sunbeam raises from the ocean. But electricity also arises with the vapour, because it always accompanies evaporation provided the water be not pure; and as the sea water contains many ingredients, a very great quantity is generated, rises with the vapour in the intertropical regions, and is poured with it into the belts of calms, in the higher regions of which there is a constant condensation from the crossing of winds of different temperatures, and tremendous thunderstorms are almost of daily occurrence, accompanied by torrents of rain. The equatorial belt of calms lies mostly N. of the equator in the Atlantic: in it these winds meet, and being highly elastic they ascend, till by the cold of the atmosphere they are condensed into the *Cloud-ring*, a stratum of clouds which surrounds the earth and overhangs the belt of calms, but leaves the sky clear on each side. New vapour is continually rising to the under surface of this cloud-ring, is condensed, and falls in constant rains: these rains fall during the day, and morning and evening are free from storms.

In the belt of calms the air, being greatly heated by the vertical rays of the sun, ascends, drawing with it the whole mass of vapour which the trade winds have brought with them, and which has been greatly added to by the rapid evaporation from the belt of calms; this vapour is condensed as it rises to the line of junction of the lower and upper 'trades.' The discharge is in some cases so copious that fresh water has been collected from the surface of the sea.

---

[1] Local circumstances have great influence, especially in the vicinity of mountains: probably the greatest average annual rainfall is that at Cherraponjee, on the Khasya Hills, at the head of the Bay of Bengal, where it amounts to 610 inches. At Guadaloupe it is 286 inches. In England the average annual quantity is 32 inches.—Greenwich Meteor. Register.

The regularity of the daily rains in the belt of calms is only fully seen in the Pacific Ocean.

It has been mentioned that the whole zone of trade winds and calms follows the sun in declination. Thus the equatorial belt of calms with its cloud-ring moves annually in the Atlantic from 5° S. lat. to 12° N., and back again. In countries situated between 5° and 10° S. and N. lat., there are two rainy seasons, and two dry: one, which lasts between 3 and 4 months, occurs when the sun passes the zenith in his way to the nearest tropic, and the other at his return ; but in the latter, which is not longer than 6 weeks or 2 months, the rains are less violent. With regard to the tropical belts of calms and rains, when the sun is N. of the equator rains prevail in the calms of Cancer, and when he is S. of that line under the calms of Capricorn: hence, in all the latitudes over which these range, one period of the year is extremely wet and the other extremely dry ; the change takes place at the equinoxes. At sea, within the limits of the trade winds themselves, it seldom rains.

Although the quantity of water which falls between the tropics in a month is greater than that of a whole year in Europe, yet the number of rainy days increases with the latitude, so that there are fewest where the quantity of rain is the greatest. Neither does it fall continually during the rainy season between the tropics, for the sky is generally clear at sunrise, it becomes cloudy about 10 in the morning, at noon the rain begins to fall, and, after pouring for four or five hours the clouds vanish at sunset, and not a drop falls during the night, so that a day of uninterrupted rain is very rare.[1]

Professor Secchi observes as a remarkable coincidence that the period from noon to four or five o'clock should be exactly the time when clouds are formed at Rome, and which corresponds with the minimum of the diurnal range of the barometer at Rome and elsewhere over the globe.

The fall of rain depends much upon the direction of the land and mountains being parallel or perpendicular to the course of the prevailing winds For instance, South and Central America run across the line of direction of the trade winds and calms, which, coming loaded with vapour, pour down torrents of rain on the extensive eastern plains to feed the rich vegetation and supply the tributaries of the Orinoco and Amazon with water, so that when they reach

---

[1] At Portree, in Skye, 12½ in. fell in 13 hours, in the year 1863. The quantity that falls in Italy is sometimes very great ; at Rome half the yearly average quantity fell on one occasion in 15 hours.

the Cordilleras of the Andes they have just moisture enough left to whiten them with snow, and descend to the arid soils of Peru and New Mexico as dry and parching winds. The northern part of Chile is under the same influence during that season which is our winter; but when the sun goes N. with his attendant trade winds and calms, Chile is left to the extra-tropical N.W. winds, which, cooled by the temperature on the tops of its stupendous Andes, deposit abundance of moisture.

In Chile and the S.W. part of America winter is the rainy season; while on the E. side of the Cordilleras, in the interior of the chain, the rains occur in summer. In Tierra del Fuego and the extreme point of the continent the two climatological provinces meet, periodical precipitation disappears, and it snows and rains throughout the year in torrents. At Cape Horn the quantity of rain which fell in 41 days measured nearly 154 inches. This excessive fall occurs along the whole western shores of Patagonia, from the Strait of Magellan to Cape Tres Montes, a circumstance owing to the high and rugged coasts, and the prevailing extra-tropical N.W. winds that traverse the Pacific loaded with vapour.

The monsoon region furnishes another instance of the effect of mountain chains upon the fall of rain. Throughout the whole of that region it is not the sun directly, but the winds, that regulate the periodical rains. That region extends from the E. coasts of Africa and Madagascar across the Indian Ocean to the N. districts of Australia, and from the tropic of Capricorn to the face of the Himalayas, the interior of China to Corea, and even round the N. of Siberia inclusive. In India and the Eastern Peninsula the W. coasts are watered during the S.W. monsoon, which prevails from April to October; and the E. coasts during the N.E. monsoon, which blows from October to April. For example, the S.W. wind condenses the vapour on the summit of the Ghats, and violent rains fall daily on the coast of Malabar, while on the coast of Coromandel the sky is serene. Exactly the contrary takes place during the N.E. monsoon; it rains on the coast of Coromandel while there is fair weather on the Malabar coast, and the table-land of the Deccan partakes of both. In the southern hemisphere the rainy season corresponds with the N.W. monsoon, and the dry with the south eastern.

Since heat is the cause of evaporation, rain is very unequally distributed, and with it decreases from the equator to the poles. From the island of Haiti in the Antilles to Uleàborg in Finland the annual quantity of rain that falls decreases from 107 to 13 inches. It is, however, more abundant in the New World than in the Old. The following rainfalls in the tropics are interesting:—

Singapore, 97 inches; Canton, 78 inches; St. Benoit, Isle of Bourbon, 163 inches; Sierra Leone, 87 inches; St. Domingo, 107 inches; Bahamas, 52 inches; Vera Cruz, 183 inches; Doldrums of the Atlantic, 225 inches; Maranhão, 280 inches. The rainfalls of temperate regions vary—in the United States between 27 and 66 inches, and in Europe from 104 inches in the Alps to 15 inches in some parts of Sweden and Russia.

The greatest quantity of rain falls on the slopes of the mountains, on which prevailing winds first strike after having blown across the greatest extent of ocean. The more abrupt the elevation, and the shorter the distance between the mountains and the sea, the greater the amount of precipitation. For instance, on the western Ghats the mean annual quantity is 302 inches. But the fall of rain on the Khasya Hill is the greatest on record, amounting, as has been already said, to 610 inches per annum. This terrific rainfall is attributed to the abruptness of the mountains which face the Bay of Bengal, and the intervening flat swamps 200 m. in breadth.

The extent of country on which rain seldom or never falls amounts to 5,500,000 sq. m. The most extensive rainless desert stretches from Morocco eastward through North Africa, Arabia, Persia, and the desert province of Mekran in Baluchistan, occupying a space of 80° of longitude and 17° of latitude. The Desert of Gobi and part of Mongolia form another rainless region in the great continent; while in the New World the rainless districts are the table-land of Mexico, part of Guatemala, California, and the region that extends from the western declivity of the Andes in Peru to the shores of the Pacific. It will easily be seen, by reference to Mr. Keith Johnston's Chart of Rains, that the prevailing winds are deprived of their vapour by condensation before arriving at these rainless deserts. The Kalahari Desert in South Africa, and Australia, suffer from periodical droughts; but the periods of their occurrence are not yet ascertained. The Pampas of South America are also subject to droughts, though they are not periodical, nor do they last more than a season.

Between the tropics it rains rarely during the night, and for months together not a drop falls; while in the temperate zone it often rains in the night, and rain falls at all seasons, though more abundantly in some than in others. It seldom rains in summer throughout the N. of Africa, Madeira, the S. parts of Spain and Portugal, Sicily, S. Italy, all Greece, and the N.W. part of Asia; but it falls copiously during the other seasons, especially during the winter; consequently that extensive region is called the province of winter rains. In the strictly western districts

of Scotland, December, January, and February are the rainiest months.

The province of autumnal rains includes all Europe S. of the Carpathians, western France, the delta of the Rhine, N. and W. Scandinavia, and the British Isles; throughout these countries more rain falls in autumn than in the other three seasons.

The province of summer rains comprises the E. parts of France, the Netherlands (with the exception of the delta of the Rhine), the N. of Switzerland, all Germany, the Carpathian Mountains, Denmark, S. Scandinavia, all Central Europe, and the countries beyond the Ural Mountains to the interior of Siberia, where showers are very rare in winter. In some places it rains almost perpetually, as in the Island of Sitka, on the N.E. coast of North America, where the year has sometimes passed with only 40 days of fair weather.

South Africa and Australia resemble each other in their rainy seasons, which in both countries are during the winter months.

The number of rainy days depends upon the direction of the wind. In Continental Europe, if the wind always blew from the N.E., it would seldom rain, because it blows over a great extent of continent; whereas it would never cease raining were the wind always to blow from the S.W., because it would ever come loaded with vapour from the Atlantic. Hence the greatest quantity falls on the W. coasts of Great Britain and Ireland, the coast of Scandinavia, the Eastern Alps, and the centre of Portugal; in the last two it depends partly on the height and form of the mountains. In W. Europe it rains on twice as many days as in the E. part: in Ireland there are three times as many rainy days as in Italy or Spain. In fact, on the W. side of Ireland it rains on 208 days out of the 365; in the Hebrides and W. parts of Scotland perhaps still more. In England, France, and the north of Germany, there are from 152 to 155 rainy days in the year; the number decreases towards the interior of the continent, so that in Siberia it only rains on 60 days in the year. Occasionally it rains over a wide extent of country at the same time; on February 2, 1842, it rained in North America over 1400 m. in length, but the breadth to which it extended was not ascertained. Rain sometimes falls without visible clouds, from a partial condensation of vapour; Sir James C. Ross mentions a smart shower with a cloudless sky in the South Atlantic on December 20, 1839; it continued for an hour.

§ 4. **Snow.**—When the temperature of the air is near the freezing point or below it, snow falls instead of rain; but the colder the air the less moisture does it contain, consequently the less snow falls, which is the reason of the comparatively small

quantity on the high plains of Tibet and of the Andes. Snow sometimes assumes the form of grains, but is generally in regular crystals of great beauty, varying in form according to the degree of cold. Dr. Scoresby, whose voyages in the Polar Seas afforded him constant opportunities of studying them, mentioned five principal kinds of snow crystals,[1] each of which had many varieties, in all known to amount to more than 1000. The whiteness of the snow is owing to the reflection of light from the minute faces of its crystals, which are like so many small mirrors.

Snow never falls between the tropics except on the tops of very high mountains. The mean elevation of the *line of perpetual snow* above the level of the sea in these hot regions is about 15,207 ft., from whence it decreases on both sides, until it grazes the surface of the earth at the Arctic and Antarctic Circles, subject, however, to various flexures. In the Andes, near Quito, the lowest level has an elevation of 15,795 ft.; from thence it varies very irregularly both to the N. and S. In 18° N. lat. it descends to 14,772 ft. on the mountains of Mexico, while on the S. it rises to 18,000 ft. in some parts of the W. Cordillera of the Bolivian Andes, owing to the extensive radiation and the ascending currents of heated air from the subjacent plains and valleys. The line is at an altitude of 17,000 ft. on the W. Cordillera, whence it sinks to 13,800 ft. at Copiapo, and to 12,780 near Valparaiso; it is only 7960 ft. in the Chilian Andes, on the volcano of Antuco, lat. 37° 40′, and 3390 in the Strait of Magellan. In lat. 31° N. the snow line is at an elevation of 12,980 ft. on the S. side of the Himalayas, and at 16,620 ft. on the N. side; while Captain Gerard gives from 18,000 to 19,000 ft. as its altitude on the mountains of the table-land of Tibet N. of the upper valleys of the Indus and Sutlej. On Mont Blanc the line is at the height of 8500 ft., so that mountain is snow clad for 7000 ft. below its summit. In the Pyrenees it is at 8184 ft., and at the Island of Mageroe, on the coast of Norway, it is at 2160 ft. above the Polar Ocean.

In the S. hemisphere snow never falls on the low lands at the level of the sea N. of the 48th parallel of latitude, on account of the predominance of water, whereas in the N. hemisphere it falls on the plains in much lower latitudes, on account of the excess of land; but its limit is a curved line, on account of the alternations of land and water. In the W. part of the great continent the

[1] Viz.:—1. Thin plates, the most beautiful and multiform class; 2. A central nucleus studded with spicules; 3. The six-sided (very rarely the three-sided) prism; 4. Six-sided pyramids; 5. A prism with plates perpendicular to it at equal distances.

S. limit of the fall of snow on the low lands nearly coincides with the 30th parallel of N. lat., so that it includes all Europe. In the American continent it follows nearly the same line, extending through the S. parts of the United States. In China snow falls at the level of the sea as far south as Canton; on the N.W. coast of America, on the contrary, it does not fall at that level till about 48° N. lat.—these are the two extremes. Although Europe lies within the region of snow, the quantity that falls is very different in different places, increasing greatly from S. to N. On an average it snows only one day and a half at Rome in the year, while at St. Petersburg there are 171 snowy days; but in that city the quantity of rain is to that of melted snow as 1000 to 384. Snow, by protecting the ground from cold winds, as well as by its slow conducting power and by preventing radiation, maintains the earth at a higher temperature than it otherwise would have. In Siberia the difference between the temperature of the ground beneath the snow and that of the air above it has amounted to 38° Fahr.

Sleet, which is formed of small particles of rounded hail mixed with rain, falls in squally weather in spring and autumn. True hail, when large, is pear-shaped, and consists of a nucleus of frozen snow coated with ice, and sometimes with alternate layers of snow and ice. Hailstones have often fallen as large as the egg of a hen, or even that of a goose. The masses and blocks of ice of great size which have not unfrequently fallen, appear to have been formed by the agglomeration of hailstones of large size frozen together; one the size of a millstone fell near Seringapatam, which it required three days to melt. It appears to be formed in the high cold regions of the atmosphere by the sudden condensation of vapour during the strife of opposing winds, and is intimately connected with electricity, since its fall is generally accompanied with thunder and lightning. Hail showers are of short duration, exceedingly partial, and extend over a country in long narrow bands: one which took place on July 13, 1788, began in the morning in the S. of France and reached Holland in a few hours, ravaging a narrow line of country in its passage. On September 31, 1856, a strip of country near Florence was ruined during a violent thunderstorm by hailstones weighing 12 and 14 ounces.

Local circumstances, no doubt, have a great influence on the formation of hail: it occurs more frequently in countries at a little distance from mountains than in those close to them or farther off, and at all hours, but most commonly at the hottest time of the day, and rarely in the night. In the interior of Europe one half of the hailstorms take place in summer. Hail is rare on the tropical plains, and almost altogether unknown; it falls at times at heights

of 1700 or 1800 ft., and even at still greater elevations—in the Bolivian Andes, for example, above 13,000, and on the table-land of Ethiopia at heights between 6000 and 10,000 ft. The same has been observed in India, where hailstorms occur in the lower regions of the Himalayas and in the Nilgiris at elevations of 3000 and 6000 ft.[1] If the air is very cold throughout the greater part of the stratum through which hail falls, it is probably increased in size during its descent; and, on the contrary, large drops of rain which precede a thunderstorm are supposed to be hail melted in its passage through low warm air. Thus the thin impalpable air is the storehouse of vapours, clouds, and storms, breathing softly over sea and land, and watering the earth with gentle showers at one time, and at another rushing with the fury of the hurricane, or heaving along the dark cloud with the thunderbolt, the hail, and the torrent. It carries warmth to melt the winter snow, and cold to temper the summer heat; viewless as it is, it contains the solid matter which feeds vegetation, from the impenetrable forest of the equator to the lichen which so scantily covers the polar rocks, and on it every creature that exists on the land or in the waters depends for life, and heat, and nourishment.

§ 5. **Light.**[2]—We know nothing of the size of the ultimate

---

[1] Buiston, 'Hailstorms in India,' in 'Transactions of Bombay Geographical Society,' vol. xii.

[2] The celestial regions are filled with an extremely rare and highly elastic medium or ether, whose particles are capable of receiving the vibrations communicated to them by self-luminous bodies, and of transmitting them to the optic nerves of the eye, so as to produce the sensation of light. The intensity of light depends upon the extent of the vibrations of the particles of ether, while its colour depends upon their frequency. Heat, like light, is a vibration of the particles of ether; they are both forces, and act as such. In fact, heat is merely a force of expansion, which increases the distance between the particles of a body till it is balanced by their mutual attraction, and in that state it is insensible to the thermometer, but it becomes sensible by compression. Thus the heat in the air may be squeezed out so as to ignite tinder; consequently it is *changed into light*. Hence *latent heat* and *caloric* are no longer admissible terms, for the former is a *force of expansion*, and the latter is simply a *force*. It is now proved beyond a doubt that light, heat, chemical action, electricity, and magnetism, are forces, or rather powers, subject to dynamical laws, and that they are correlative, or that they mutually produce or merge into one another. Thus heat produces electricity, and electricity produces heat; chemical action produces light, and light produces chemical action, &c. All are correlative with one another or with motion; nevertheless, they can only act on one another through the medium of matter which is permeable to the ether. It is evident that the idea of electricity and magnetism being fluids must be rejected; they are *powers*, and act on matter as such.—See the 'Connexion of the Physical Sciences,' by Mary Somerville.

particles of matter, except that they must be inconceivably small. The air is only visible when in mass; the smallest globule of steam tells no more of its atoms than the immensity of the ocean; the minutest grain of sand magnified appears like the fragment of a rock —no mechanical division can arrive at the indivisible. Although the ultimate atoms are beyond the power of vision, chemical compounds show that the divisibility of matter has a limit, and that the particles have different densities; moreover, the cleavage of crystalline substances affords reason to believe that they have different forms.[1] Thus the reasoning power of man has come to the aid of his imperfect sense of vision, so that what were before imaginary things are now real beings with definite weights, and united by fixed laws. Though nothing had been known of their *size*, their *effects* were evident in the perceptions of sweet and sour, salt and bitter, and in the endless varieties of aroma in the food we eat and the liquors we drink. Every substance on earth is merely a temporary compound of the ultimate atoms, sooner or later to be resolved into its pristine elements, which are again to be combined in other forms, and according to other laws; so that literally there is nothing new under the sun, for there is no evidence of new matter being added to the earth, except in the case of meteorites, nor of that which exists being annihilated. Fire, which seems utterly to destroy, only resolves bodies into their elementary parts, to become what they were before, the support of animal or vegetable life, or to form new mineral compounds. It is to the action of these particles on the light of the sun that nature owes all its colours.

When a sunbeam passes through a glass prism,[2] an oblong image of it is formed, consisting of colours in the following order: red, orange, yellow, green, blue, indigo, and violet. Sir John Herschel discovered lavender rays beyond the violet, and dark red rays exterior to the red, which are not so easily brought into evidence as the rest.

Even the most transparent substances absorb light; air, water, the purest crystal, arrest some of the rays as they pass through them. A portion of the light is also reflected from the surface of all bodies; were it otherwise they would be invisible. We should be uncon-

[1] The reader is referred to the 'Connexion of the Physical Sciences' for an account of Dalton's theory of definite proportions, and the relative weight of atoms; and to Dr. Daubeny's work on the Atomic Theory.

[2] The reader is referred to the 18th section of the 'Physical Sciences' for reflection, refraction, and absorption of light, and to the 19th section for the constitution of the solar light and colours.

scious of the presence and form of material substances beyond our reach except by the reflected rays,—

> The mist of light from whence they take their form
> Hides what they are.

As the same light does not come to all eyes, each person sees his own rainbow, the same flower by different rays. White substances reflect all the light, black substances absorb all but that which renders them visible, while coloured bodies decompose the light, absorb some of the colours, and reflect or transmit the rest. Thus a violet absorbs all but the violet rays, which it reflects; a red flower only reflects the red and absorbs the rest; a yellow substance absorbs all but the yellow. In the same manner transparent substances, whether solid or fluid, absorb some colours and transmit others: thus an emerald absorbs all but the green, a ruby all but the red; whereas a diamond does not decompose the light, but transmits every ray alike. Very few, however, of the colours, whether transmitted or reflected, are pure, but the substance takes its hue from the colour that predominates.

The atmosphere, where rarefied, absorbs all the colours of the sun's light except the blue, which is its true colour.[1] In countries where the air is pure the azure of the sky is deep; it is still more so at great elevations where the density of the air is less; and its colour is most beautiful as it gradually softens the outlines of the mountains into extreme distance, or blends the sea with the sky. When the sun is near the horizon the atmosphere, on account of its superior density, absorbs the violet and blue, and leaves the yellow and red rays in excess; that property, together with the refractive power of the aqueous vapour, which is most abundant near the earth's surface, gives the roseate hue to the early morning, and the gold and scarlet tints to the closing day. The blending of these colours with the blue above produces that beautiful vivid green so frequently seen in Italy and other warm countries. The last reflected rays of the setting sun are red, which gives a rose coloured tint to the Alpine snows, and below the red the shadow of the earth is sometimes cast upon the atmosphere in the form of a deep blue segment, known as the ante-twilight. The air reflects and scatters part of the white solar beams, whence the brightness and cheerfulness of day; were it not for that reflective power, the sun and moon would be like sharply defined balls of fire in the profoundly black vault of the heavens, and dark night would instantly

---

[1] Professor Tyndall has proved that the blue colour of the sky is owing to the reflection of the blue rays of the sun by infinitesimal particles of aqueous vapour floating in the highest regions of the atmosphere.

follow sunset. When the sun is 18 degrees below the horizon, the air, at the height of 30 m., is still dense enough to reflect his rays, and divide the day from the night by the sober shades of twilight. Between the tropics twilight continues from the setting of the sun till he is 16 degrees below the horizon, in middle latitudes until he is 18 degrees, and in the polar regions until he is 20 degrees; then and then only does real night begin: at Edinburgh there is no real night from May 6 until August 7, in London there is none from May 21 till July 22, and in Paris there is no true night in the month of June.

A considerable portion of the sun's light is absorbed by the atmosphere: the loss increases with the obliquity of incidence and the density of the air. It is diminished 1300 times by the thickness of the air at the horizon, which enables us to look at the sun when setting without being dazzled.[1]

§ 6. **Mirage, &c.**—The bending or refraction of the sun's light passing through the atmosphere causes distant objects, as mountains, to appear higher than they are. It increases with the density of the air and the obliquity of incidence, and on that account the sun is seen above the horizon after he is really below it, or has set, and also before he has really risen. During the winter of 1820, which the expedition under Sir Edward Parry passed at Melville Island, in 70° 47′ N. lat., the sun did not rise for 92 days; but in consequence of extraordinary refraction he appeared above the horizon on February 3, which was three days sooner than he ought to have done, unaided by refraction.

The sun and moon often appear distorted at their rising and setting, because the looming, or extraordinary refraction, is greatest in the morning or evening, from the increased density of the air

---

[1] The *Photometer* is an instrument invented by the late Sir John Leslie for measuring the relative intensity of light and its variations, upon the principle that the heat contained in solar light is a measure of the intensity of light. Sir John computed that one fourth of the light of the sun is absorbed by the atmosphere, and, with regard to obliquity of incidence, that, out of 1000 rays which fall obliquely on the earth, only 378 reach it at the equator, 288 in lat. 45°, and 110 at the poles; in England the light measured by the photometer is 65° greater in intensity in summer than in winter.

Professor Secchi says that Leslie's photometer is now acknowledged to be a simple thermometer: as light can be said to be efficient on earth as accompanied by heat and chemical action, so the measures by the photometer of Leslie, or actinometer, are very useful, but they should be accompanied also by a study of, and researches on, chemical action, which until lately were omitted. The observations of Professors Rouse and Bunsen on the diurnal and annual variation in the actinic power of light promise to add much to our knowledge on this subject.

at the surface of the earth by reason of the cold. This distortion of objects is occasioned by the rays of light passing through strata of air of different densities; from this cause objects are sometimes seen inverted, and three images of the same object occasionally appear, two direct and one inverted.

Mirage, or the delusive appearance of water, so frequent in deserts, is owing to the reflection of light between two strata of air of different densities, occasioned by the radiation of heat from the arid soil. It is very common on the extensive plains of Asia and Africa, and especially in Upper Egypt; villages on small eminences above the plain appear as if they were built on islands in the middle of a lake when the dry sandy ground is heated by the mid-day sun. Sometimes objects appear double, and occasionally several images appear above one another, some direct and some inverted; this is particularly the case in high latitudes, where the Icy Sea cools the stratum of air resting on it.[1]

In the polar regions or on the tops of mountains when the sun is on or near the horizon the shadow of a person is sometimes thrown on an opposite cloud or mist, the head being surrounded by concentric coloured rings or circles, the number varying from one to five. Dr. Scoresby saw four of these rings on one occasion round the shadow of his head, as he stood between the sun and a thick low fog: the first ring consisted of concentric bands of white, yellow, red, and purple; the second consisted of bands of blue, green, yellow, red, and purple; the third of green, white, yellowish white, red, and purple; and in the fourth the bands were greenish white, deeper on the edges. Mr. Green, at the height of 2 m., saw the shadow of his balloon, surrounded by three coloured rings, on a cloud below. These appearances, called *glories,* or *fog images,* and the coronæ, or small concentric coloured circles which surround the sun or moon when partly obscured by thin white clouds, are owing to the refraction of the light in the aqueous particles of the cloud or fog. The colours in the concentric bands of the coronæ, however, differ from the foregoing; that nearest the sun is of deep blue, white, and red; the circle exterior to that consists of purple, blue, green, pale yellow, and red; but the series is very rarely complete.

Halos, which surround the sun in large circles, or a complicated combination of circles are, on the contrary, supposed to be produced by the light falling on minute crystals of ice suspended in the atmosphere; they are particularly brilliant and frequent in high latitudes. It is scarcely possible to give an idea of these beautiful and singular objects. Sometimes a large coloured circle

---

1 For the cause of mirage, see the 'Connexion of the Physical Sciences.'

surrounds the sun or passes through his centre, which is occasionally touched or cut by segments of others. One seen at St. Petersburg on June 29, 1790, consisted of four coloured circles of different sizes intersecting each other, which were either cut or touched by segments of eight others, and at the points of intersection mock suns or parhelia appeared. The sky is very hazy on these occasions. Mock suns, without circles and halos, are by no means uncommon, and halos are often seen round both sun and moon, but seldom of that complicated kind. They are situated between the observer and the sun, whereas the rainbow is always in that part of the sky opposite the sun, because it is produced by refraction and reflection of the sun's rays in the drops of rain; and when the light is intense and the rain abundant, there are two concentric bows, the prismatic colours of the innermost of which are the most vivid, the violet being within and the red outside: sometimes the inner edge exhibits a repetition of colours in fine fringes, in which red and green predominate. The colours are reversed in the exterior bow, the violet being outside and the red on the inner edge. Besides these two principal and most common bows, supernumerary rainbows occasionally appear within the interior bow, generally green and violet, though they are sometimes more or less perfect repetitions of all the colours.[1] The visible extent of the bow depends upon the altitude of the sun and the position of the spectator. As a line joining the centres of the sun and bow must pass through the eye of the spectator, the altitude of the sun must be less than 45°, and only a portion of the bow can be seen from a plain; but the complete circle may be visible to a person on the top of a high mountain when the sun is low, except the small portion intercepted by his shadow. In squally weather a rainbow is sometimes seen on a blue sky when rain is falling, but it is generally on clouds; it is constantly seen when the sun shines on the fine drops of fountains and cascades, and on the grass in a dewy morning. As the light of the moon is feeble, lunar rainbows are rare and, for the most part, colourless. In the early morning, when the sun throws his slanting beams across the fields, a miniature bow, with all its vivid colours, may be seen in each dewdrop as it hangs on the points of the bending grass.

§ 7. **Polarisation of the Atmosphere.**—Light is said to be *polarised* when, after having been once refracted or reflected, it is

[1] In the primary bow the light is twice refracted and once reflected in the rain drops, while in the external bow it is twice refracted and twice reflected; and as light is lost at each refraction and reflection, the interior bow is the brightest. Sir David Brewster found that the light of the rainbow is polarised.

rendered incapable of being again refracted or reflected at certain angles. For examplef if a crystal of brown tourmaline be cut longitudinally into thin slices and polished the light of a candle may be seen through a slice as if it were glass. But if one of these slices be held perpendicularly between the eye and the candle, and a second slice be turned round between the eye and the other plate of tourmaline, the image of the candle will vanish and come into view at every quarter-revolution of the plate, varying through all degrees of brightness down to total or almost total evanescence, and then increasing again by the same degrees as it had decreased. Thus the light, in passing through the first plate of tourmaline, is said to be polarised, because it has been rendered incapable of passing through the second piece in certain positions.

A ray of light acquires the same property if it be reflected from a pane of plate glass at an angle of 57°; it is by that rendered incapable of being reflected by another pane of plate glass in certain definite positions, for the image of the light vanishes and reappears alternately at every quarter revolution of the second pane.

If a thin plate of mica be interposed when the image of the candle has vanished, the darkness will instantly disappear, and a succession of the most gorgeous colours will come into view, varying with every inclination of the mica from the richest reds to the most vivid greens, blues, and purples. The most splendid colours arranged in symmetrical forms are exhibited by thin plates of an infinite variety of substances besides mica. They display some of the most beautiful objects in nature, and show differences otherwise inappreciable in the arrangement of the molecules of crystalline bodies.[1]

Arago discovered that the light of the sun is polarised by the reflection of the atmosphere, but not equally so on every part of the sky; the polarisation is least in the vicinity of the sun, and greatest at 90° from him, for there his light is reflected at an angle of 45°, which is the polarising angle for air.[2] There are three points in the sky where the light is not polarised: one of these neutral points, discovered by M. Arago, is 18° 03′ above the point diametrically opposite to the sun when he is in the horizon; the second neutral point, discovered by M. Babinet, is 18° 30′ above the sun when he is rising or setting; and the third, discovered by Sir David Brewster, is 15° or 16° below the sun. These points vary with the height of the sun, and the two latter rise and coincide in his centre when he is in the zenith.[3]

---

[1] For phenomena and theory of polarised light, see section 21, 'Connexion of the Physical Sciences.'

[2] Every substance, whether solid or fluid, has its own polarising angle.

[3] The reader is referred to a plate in Johnston's folio 'Physical Atlas' showing the phenomena of the polarisation of the atmosphere.

Now the portion of polarised light sent to the eye from any part of a clear sky is in a plane passing through that point, the eye of the observer, and the centre of the sun. If that point be the N. pole of the heavens, it is clear that as the sun moves in his diurnal course, the plane will move with him, as an hour circle, and may be used as a dial to determine the hour of the day. Professor Wheatstone, by whom that beautiful application of the polarisation of the atmosphere was made, constructed a clock of very simple form which shows the time of day with great accuracy, and which has many advantages over a sun dial.

§ 8. **Electricity.**—Electricity pervades the earth, the air, and all substances, without giving any visible sign of its existence when in a quiescent state, but, when elicited, it exhibits forces capable of producing the most sudden, violent, and irresistible effects. It is roused from its dormant state by every disturbance in the chemical, mechanical, or calorific condition of matter, There are two kinds of electricity, positive and negative.[1] When bodies have different kinds of electricity they attract each other, and, when not opposed, the electricity coalesces with great rapidity, producing the flash, explosion, and shock, and that with the more violence the greater the tension or pressure of the electricity on the surrounding air which resists its escape. Equilibrium is then restored, and the electricity remains quiescent till called forth by a new exciting cause. When similarly electrified they repel each other. The electrical state of substances is easily disturbed, for without contact positive electricity tends to produce negative electricity in a body near it, and *vice versâ* : the latter is then said to be electric by induction.

The electricity of the atmosphere arises from evaporation, condensation, and the chemical changes that are in perpetual progress on the earth's surface ; no electricity, however, is developed by the evaporation of pure water, but it arises abundantly from water containing matter susceptible of chemical action during the evaporation ; consequently the ocean is one of the greatest sources of atmospheric electricity ; it ascends with the vapour into the higher regions of the atmosphere, where there is always a great quantity of positive electricity, which, like the magnetism of the atmosphere, increases with the diminished temperature, and accounts for the violent electrical explosions on the high plains of the Andes; and the Acroceraunian Mountains have obtained their name from the frequent thunderstorms to which they are liable. *Combustion* is another source, and a large portion arises from vegetation. The air, when pure, is almost always positively

[1] See sections 28 and 29 of the 'Connexion of the Physical Sciences:' on Electricity.

electric; but as the chemical changes on the earth sometimes produce positive and sometimes negative electricity, it is subject to great local variations; a passing cloud or a puff of wind produces a change, and a distant storm renders it negative for the time, but the earth is always in a negative state. The quantity of electricity varies with the hours of the day and the seasons; it is more powerful in the hours after sunset, from which it becomes less as the night advances, in winter than in summer, and it diminishes from the equator to the poles. It thunders daily in many places, in others never, as on the E. coast of Peru and in the Arctic regions, except where there are violent volcanic explosions, which always generate electricity, as in Iceland. Wherever there are no trees or high objects to conduct it to the ground, the quantity of positive electricity increases with the height above the surface of the earth. Violent thunderstorms take place on the highest summits of the Andes and Himalaya Mountains. La Condamine encountered a violent thunderstorm on a peak of the Cordilleras at the height of 15,970 ft. On the high table-land of Ethiopia they are violent, and so frequent, that M. d'Abbadie calculated that it thunders 56 out of every 100 days. In general, thunder-clouds in our latitudes float at the height of from 3000 to 5000 ft. above the earth, though observers on the summit of hills, less than a quarter of a mile in height, have seen thundershowers below them.

Electricity becomes very strong when dew is deposited, especially after sundown, and in some cases it is strongly developed in fogs. Mr. Cross found it so powerful on one occasion that it was dangerous to approach the apparatus for measuring its intensity. A continued succession of explosions lasted nearly 5 hours, and the stream of fire between the receiving ball and the atmospheric conductor was too vivid to look at. M. Peltier found that the common fogs arising from the mere condensation of the moisture in the air are neutral, but that others which are produced by exhalations from the earth are sometimes positive, sometimes negative; the subject, however, requires further investigation.

Though in long continued mild rains there are no traces of electricity, yet when rain or snow falls from the higher regions of the atmosphere it is more or less developed, sometimes positive, sometimes negative, depending a good deal on the direction of the wind. During a shifting fall of snow Mr. Cross elicited electricity enough to decompose water. The atmosphere being positively electric, negative rain is supposed to arise from the evaporation of the drops in passing through dry air; the vapour carries off the positive electricity and leaves the drop in a negative state—a cir-

cumstance which seems to be confirmed by the electricity of cascades, near which there always is more or less negative electricity; the positive is conducted into the earth, while the other remains united to the drops of the cascade.

The inductive action of the earth upon the clouds, and of the different strata of clouds on each other, produces great variations in their electrical state. If rain falls from the lowermost of two strata of positively electrical clouds, the inductive action of the earth renders the under surface positive and the upper negative, and the rain is positive. By and by the under surface of the cloud and the earth become neutral; and after a time the lower cloud becomes charged with negative electricity by the induction of the upper strata, and the rain is then negatively electric. Clouds are very differently charged; and when clouds differently charged meet, an explosion takes place. When the sky is clear and the air calm and warm, a succession of small white fleecy clouds rising rapidly above the horizon and flying swiftly in the very high regions of the atmosphere, is a certain presage of a thunderstorm.

Electricity of each kind is probably elicited by the friction of currents of air, or masses of clouds moving rapidly in different directions, as in thunderstorms, when small white clouds are seen flying rapidly over the black mass; yet the quick and irregular motion of clouds in storms is probably owing to the strong electrical attraction and repulsion among themselves, though both may be concerned in these hostile encounters. When two clouds differently charged by the sudden condensation of vapour, and driven by contending winds, approach within a certain distance, the thickness of the coating of electricity increases on the two adjacent sides; and when the accumulation becomes so great as to overcome the coercive pressure of the atmosphere between them, a discharge takes place which occasions a flash of lightning. The actual quantity of electricity in any part of a cloud is very small. The intensity of the flash depends upon the extent of surface occupied by the electricity, which acquires its intensity by its instantaneous condensation.

The air, being a non-conductor, does not convey the electricity from the clouds to the earth, but the latter acquires from them an opposite electricity, and when the tension is very great the force of the electricity becomes irresistible, and an interchange takes place between the clouds and the earth; but the motion of the lightning is so rapid that it is difficult to ascertain when it goes from the clouds to the earth, or from the earth to the clouds, though there is no doubt it does both: explosions have burst from the ground, and people have been killed by them. During the Canadian expedition of 1857, Captain Palliser frequently observed, while on Lac

la Pluie and elsewhere, that the lightning flashed upwards from the earth to the impending cloud, when it often presented the appearance of a string of bright beads.

When the quantity of electricity developed by the sudden condensation of vapour is very great, the lightning is always forked; its zigzag form is ascribed to the compression of the air before the electricity, thereby opposing greater resistance, and turning the fluid aside to seek some path upon which the resistance is less. The author once saw a flash divided into four parallel streams—a very uncommon occurrence. Occasionally in very great storms the lightning sends off lateral branches. It often appears as a globe of fire, moving so slowly that it is visible for several seconds, while the flashes of forked lightning do not last the thousandth part of a second, but the impression on the eye lasts much longer. Professor Wheatstone, who measured the velocity of lightning by experiments of great ingenuity, found that it far surpasses the velocity of light. This velocity is beautifully exemplified in the electric telegraph, by which the most violent and terrific agent in nature is rendered obedient to man, and conveys his thoughts with extreme rapidity. The colour of lightning is generally a dazzling white or blue, though in highly rarefied air it is rose colour or violet. The light given out by a flash of lightning is produced by the incandescence of the particles of air through which the current of electricity passes, the oxygen, nitrogen, and moisture present being converted into certain compounds, such as nitric acid and ammonia. The light seen is therefore not the electricity itself, which being pure force is perfectly invisible, but simply the effect of it.

When the air is highly rarefied by heat its coercive power is diminished, so that the electricity escapes from the clouds in the form of diffuse lambent sheets, without thunder or rain, frequently seen in the warm summer evenings, sometimes near the zenith, and quite different from that sheet lightning at the horizon, which in general is only the reflection of the forked lightning of a distant storm. The author saw a very remarkable instance of that glow discharge from a terrace at a considerable height above Turin. Vineyards descended rapidly to the plain on one side, and a crescent of hills rose on the other. It had thundered off and on the whole day; in the evening the heat was great and the darkness intense, but brilliant flashes of lightning momentarily illuminated the valleys of the Po and Dora, and the magnificent chain of Alps that bounds them. By degrees the lightning became less frequent, and at last ceased. The air was perfectly still, and the darkness extreme, when a silvery blue light appeared in the Val de Susa, as if the moon had been rising; it spread over a great part of the Alps, along the tops of the crescent of hills behind the terrace, and

then a large column of it rose from the vineyards immediately below, and close to the terrace, which made the surrounding objects visible. There was no noise; and in ten minutes it vanished, but in about a quarter of an hour the phenomena was repeated exactly in the same manner, lasted about the same time, and was followed by a torrent of rain.

The sudden compression of air during the passage of lightning must convert a great quantity of heat of expansion into sensible heat, for heat exists in all bodies independent of their temperature. Heat is absorbed and becomes insensible to the thermometer when solids become liquids, and when liquids are changed to vapour; and it again becomes sensible when vapour is condensed, and when liquids become solids. When water freezes, all the heat that kept it liquid is given out; and when ice melts, it absorbs heat from everything near it. The air is full of absorbed heat, whatever its temperature may be, but it can be squeezed out by sudden compression so as to kindle tinder. Every aërial wave, every sound, every word spoken, must set free an infinitesimal quantity of heat; so everything that tends to rarefy the air must cause it to absorb a proportional quantity.

Thunder is considered to be the result of the sudden re-entrance of the air into a void space, caused by the lightning in its passage through the air. The electrical force communicates a powerful repulsive force to the particles of air along the path of its discharge, producing thus a momentary void, into which the air rushes again with a force proportioned to that which caused the separation. The rolling noise of thunder is evidently owing to the difference between the velocity of lightning and that of sound; the clouds at different distances giving rise to a series of echoes which reach the ear at irregular intervals. Thunder may be regarded as originating in every point of a flash of lightning at the same instant; and as sound takes a considerable time to travel, it will arrive first from the nearest point; and if the flash run in a direct line from a person, the noise will come later and later from the remote points of its path, in a continued roar. Should the direction of the flash be inclined, the succession of sounds will be more rapid and intense; and if the lightning describe a circular course above a person, the sound will arrive at the same instant from every point with a stunning crash.[1] The rolling is also partly the result of echoes.

[1] Sound travels at the rate of 1120 ft. in a second in air at the temperature of 62° Fahr.; so, if that number be multiplied by the number of seconds elapsed between the flash of lightning and the thunder, the result will be the distance in feet at which the stroke took place. A relative of the author's was fishing in the Tweed on a very sultry day, and lay down on the grass to rest: he was astonished to hear repeated peals of thunder,

In passing to the earth, lightning follows the best conductors—metals by preference, then damp substances—which is the reason why men and animals are so often struck. If it meets with a bad conductor it shivers it to pieces, and scatters the fragments to a considerable distance. A powerful flash scatters gunpowder, while a feeble one ignites it; the hardest trees are split and torn to shreds; when a tree is struck, the heat of the flash converts the sap into steam, the expansive force of which shivers the tree. The surface of rocks is vitrified by it: and when it falls on a sandy soil, its course under ground is marked vitrifying the sandy particles, and forming of them tubes many feet long.

Where the trade winds blow thunderstorms are hardly known though electric discharges are frequent in the zones of calms, at their limits. At the change of the monsoons masses of black clouds roll over the sky, the darkness is reflected from a calm sea, dead stillness and silence prevail till the 'thunder utters his voice,' and the war of the elements begins—terrible on land, but terrific in a ship far at sea.

In Greece and Italy there are about 40 thunderstorms annually, which occur in spring and autumn, while N. of the Alps they chiefly take place in summer. There are about 24 in the year on the coasts of the Atlantic and in Germany, but they are much more frequent among mountains than on plains. In the interior of the old continent they rarely occur in winter, and three fourths of the number happen in summer. In Lower Peru, where it never rains, thunder is never heard. Thunderstorms are of such rare occurrence in high latitudes, that, in a residence of six years in Greenland, Geiseke only heard it thunder once.

Some storms arise from the contention of opposite currents in the air; others are occasioned by currents of warm air ascending from the earth, which are suddenly condensed as they enter the upper regions of the atmosphere, and, as this sometimes happens at the hottest hour of the day, these storms are periodical for many successive days, recurring always at the same hour. Volcanic eruptions, whirlwinds, and waterspouts, which cause the moving of vast masses of air and the rapid condensation of vapour, are also generally attended by thunder and lightning. Sometimes they extend over a great expanse of country, and the lightning darts from all points of the compass. A person may be killed at the distance of 20 m. from the explosion by the *back stroke.* If the two extremities of a highly charged cloud dip towards the earth

as there was not a cloud to be seen in the sky; two hours afterwards clouds began to rise, and in the afternoon there was a thunderstorm; the sound had been conveyed down the river by the stream.

they will repel the electricity of the latter, if it be of the same kind with their own, and will attract the other kind; and if a discharge should take place at one end of the cloud, the equilibrium will instantly be restored by a flash from that part of the earth which is under the other, sufficiently strong to destroy life; the back stroke is the most dangerous, though never so strong as the direct one.

When thunderclouds are very low, there is frequently no lightning; the electricity produced by induction is so powerful that it escapes from pointed objects in the shape of flame, known as St. Elmo's fire. These flames are not unfrequently seen at the topmasts of ships and the extremities of their yards. Bodies between the clouds and earth may be electricised by induction, and their electricity will be seen in the form of flame, as showers of phosphorescent snow.

Phosphorescence is ascribed to electricity; various substances emit light when decaying, as fish and wood. Many marine animals are phosphorescent, and the luminous appearance which the sea sometimes assumes is principally to be attributed to this cause, although in some localities the slow combustion of the phosphorus in the decaying animal matter it contains may in a slight degree contribute to it.

§ 9. **Magnetism.**—Magnetism is one of those molecular forces which, like electricity and heat, are known only by their effects. It is evidently identical with electricity, the two forms of force being readily convertible into each other.

The action of terrestrial magnetism upon the magnetic needle is extremely complicated; the direction of the force horizontally is determined by the declination needle, or mariner's compass, and vertically by the dipping needle: they consist of magnetised needles, or bars of steel, so suspended that the declination needle revolves in a horizontal direction, and the dipping needle in a plane perpendicular to the horizon. The variations of magnetic force are determined by comparing the squares of the numbers of vibrations made by the dipping needle in a given time.

The N. end of the dipping needle sinks or dips below the horizon in the N. hemisphere, the S. end sinks or dips beneath it in the S. hemisphere, and between the two there is a line which encircles the whole earth, where the dipping needle remains horizontal. That line, which is the magnetic equator or line of no dip, crosses the terrestrial equator in two places; one lies a little to the E. of the meridian of Greenwich, and the other in 170° E. long.: it extends alternately on each side, but never deviates more than 12° or 15° from it. N. and S. of the magnetic equator the needle dips more and more, till at last it becomes perpendicular to the horizon in

two points, or rather spaces, known as the N. and S. *Magnetic Poles*, which are quite distinct from the poles of the earth's rotation. One, the position of which was determined by the late Sir James Ross, is in 70° N. lat. and 97° W. long., while that in the southern hemisphere is placed by the same celebrated navigator, from his observations in 1841 in the interior of Victoria Island, in 75° 5′ S. lat., and 154° 8′ E. long. *Lines of Equal Dip* are such as may be drawn on a globe through all those places where the dipping needle makes the same angle with the horizon. The *Mean Dip* for Great Britain in 1860 was fixed by General Sabine at 68° 59′. The *Maximum Dip* for the same year was found to be 71° 29′ 5″ at Jordan Hill, near Glasgow, the *Minimum* at St. Leonards being 67° 44′ 5″.

The *Magnetic Meridian* is the mean direction which a freely suspended horizontal needle assumes when left to itself. The magnetic meridians coincide with the geographical meridians in some places, and in these the magnet points to the true N. and S. —that is, to the poles of the earth's rotation. But if it be carried successively to different longitudes, it will deviate sometimes to the E., sometimes to the W. of the true N. Imaginary lines on the globe, passing through all places where the needle points to the poles of the earth's rotation, are *lines of no variation*; and lines passing through all places where it deviates by an equal quantity from the geographical meridians are *lines of equal variation*; they are also very irregular, and form two closed systems, or loops—that is, they surround two points, one in North Siberia, and another in the Pacific, nearly in the meridian of the Pitcairn Islands and the Marquesas.[1] The variation of the needle from the true N. in 1864 was 20° 45′ W.

---

[1] The author is indebted to the investigations of General Sabine for almost all her information on the subject of terrestrial magnetism. In these, and in his notes to the English translation of Humboldt's 'Cosmos,' the reader will find the foundation of all that is most interesting on the subject. In his own works there are plates of the course of the different magnetic curves mentioned in the text. The most practically useful element of terrestrial magnetism, the declination or variation, has of late years formed an important object of observation by the officers of our navy. A vast number have been accumulated from every quarter of the globe, at the Hydrographical Office, where they are discussed, and laid down on the charts issued by the Admiralty. The British Association Reports and the 'Philosophical Transactions' are from time to time full of interesting observations of magnetic phenomena. For those who wish to pursue the subject further, General Sabine's 'Memoir on the Observations taken at Kew and Nertschink,' 'Phil. Trans.,' 1864, and Dr. Balfour Stewart's Lecture on this subject in the Proceedings of the Royal Institution for 1864, may be consulted with profit.

The *Intensity of the magnetic force* is as variable and even more complicated than the other magnetic phenomena. From observations made in various parts of the earth it has been determined that there are four points in which the intensity is greater than anywhere else. Two of these are in the N. and two in the S. hemisphere; they neither coincide with the poles of the earth's rotation nor with the magnetic poles, nor are they all of equal intensity.

One of these foci of *Maximum Magnetic Intensity* is situated in N. America, S.W. from Hudson Bay; another is in N. Siberia, in 120° E. long. In the S. hemisphere, one of the points of maximum magnetic intensity is in the S. Atlantic, in 20° S. lat. and 324° E. long., and the other in 60° S. lat. and 131° 20′ E. long. In consequence of the unequal intensity of the force in these four foci, the decrease in magnetic power from them towards the equator is extremely irregular, so that the *Dynamic Equator*, which is a line supposed to be drawn through all the points of the earth where in each geographical meridian the intensity is the least, encircles the globe in a waving line, which coincides with neither the geographical nor magnetic equator; it forms the division between the magnetic intensities in the two hemispheres. The foci are all of different intensities; that in the S. Atlantic, discovered by M. Erman, has the least intensity of the four, and the other in the S. hemisphere, discovered by Sir James Ross, has the greatest; taking 1 as the unit at the magnetic equator in Peru, as determined by Humboldt, their intensities are as 2·071 and 0·706. In the N. hemisphere the American focus is more intense than that in Siberia, which is moving from W. to E., while the minor focus in the S. hemisphere is moving from E. to W. Lines drawn on a globe through all the points where the magnetic intensity is the same are so complicated that it is scarcely possible to convey an idea of them in words. They form a series of ovals round each of the foci of maximum force in each hemisphere. In the N. hemisphere they form the figure of 8, having a focus and its ovals in each loop; then they open into tortuous lines which encompass the globe, but which become less tortuous as they approach the dynamic equator. The complication is increased by the foci in the two hemispheres being unsymmetrically placed with regard to one another, as well as by the difference in their intensities. The measurement of magnetic intensity by British observers is referred to an absolute unit of measurement, that determined by Humboldt being purely arbitrary. The *British absolute unit* is an amount of magnetic force capable of moving one grain of matter through the space of one foot in one second of time. The magnetic intensity at London in 1864 was 10·29,

i.e. it is equal to a force that would move a mass of water weighing one grain through 10·29 ft. in one second. The minimum of magnetic intensity yet measured would be 6·4, the maximum 15·8. The minimum of magnetic intensity for Great Britain, as measured by General Sabine in 1860, was 10·626, at Fern Tower, near Crieff, situated in 56° 22′ N. lat., and 3° 50′ W. long.; the minimum measured at St. Leonards-on-Sea was 10·225, and the mean of a large number of observations made in various districts 10·332. He also found that the lines of magnetic intensity ran due E. and N., seeming to follow the isothermal very closely. The lowest minimum of magnetic force, as observed by A. Erman, was at 19° 59′ S. lat. and 10° 2′ E. long., counting from Paris. The intensity increases as it approaches the four maximum points.

Thus it appears that there are six points on the earth which form as it were centres of magnetic force, all of which are distinct from one another and from the poles of the earth's rotation: namely, two magnetic poles, where the dipping needle is at an angle of 90 degrees with the horizon, and four points which are the foci of magnetic intensity—that is, where the total magnetic force is a maximum. There are also two remarkable lines which encompass the earth, neither of which coincides with the geographical equator: namely, the magnetic equator, in every point of which the angle of the dip is zero: it encircles the earth and intersects the terrestrial equator;—and the dynamical equator, or line of minimum magnetic intensity, which surrounds the earth in an irregular line, but neither coincides with the terrestrial nor magnetic equator; besides these, there is a zone which is supposed to pass through all places where the horary variations of the magnet partake of the phenomena of each hemisphere alternately; it either partly or nearly coincides with the line of minimum intensity.

Complicated as the magnetic phenomena are, they are rendered still more so by the secular periodic and occasional variations to which they are liable. The foci of maximum intensity and the whole system of the magnetic curves are moving along the two hemispheres in different directions; those in the northern in a direction from W. to E., and those in the southern from E. to W.; and as the foci of greatest intensity move with different velocities, the forms, as well as the positions, of the curves are rapidly and ceaselessly changing, so that in the course of a few years the whole magnetic system is altered. General Sabine has shown that the weaker magnetic focus in the N. hemisphere has moved through 100 degrees of longitude in 150 years. It is now in Siberia, in about 120° E. long., and is moving E. toward America, while the American pole has been moving, but far more slowly,

in the same direction since the year 1678. The poles seem to increase in magnetic force the nearer they approach to one another, and the intensity is also increased in the space between them. Hence in the N. hemisphere the effect of the secular easterly motion of the weaker magnetic pole is to increase the magnetic dip and force E. of the 120th meridian and to diminish them to the W. of it. For example, at Toronto in Canada, the total force has a secular increase of ·0052 annually, and the dip or inclination, which was 75° 17′·63 in 1840, has an annual increase of 1′·0. Moreover, the declination has a secular westerly increase, the rate of which is augmenting, for at the end of 1851 the mean annual increase was 1′·952, at the end of 1854 it was 2′·54, and at the end of 1855 it was 3′·4. On the contrary, the total force is decreasing in Europe, and at London there is an annual decrease of 2′·7 in the inclination, and of 7′ in the declination westerly.

In the S. hemisphere the force is greater in the principal pole than in the pole of maximum intensity in the northern, probably because the foci of maximum force are only 90 degrees apart, while in the N. hemisphere they are 150 degrees. In the S. hemisphere the secular fluctuations are in an opposite direction to those in the northern. At St. Helena the declination has increased during the last 200 years at a nearly uniform rate of 8′ annually. It takes place in equal aliquot portions in each of the twelve months; whence General Sabine infers that the secular changes must proceed from causes which act with surprising uniformity and regularity through a long succession of years. The laws and causes of these secular variations are unknown; their discovery is reserved for future generations, who will have the advantage of the most extensive and perfect system of observation that has ever been made on the state of terrestrial magnetism, and the charts which represent them form a magnetic epoch whence all future changes may be estimated.

The three magnetic elements, the total force, inclination, or dip, and the declination, are subject to annual variations depending upon a variety of causes, at present involved in some obscurity, which sometimes appear to unite and produce violent disturbances, more or less irregular in all their magnetic elements, and known as magnetic storms. These simultaneous disturbances are closely watched in different parts of the world, and the observations, of which there are now some millions, show that they are frequently simultaneous over a large portion of the earth's surface. A notable magnetic storm was simultaneously perceptible at Toronto, Cape Prague, and Hobarton. Another was simultaneously felt in Sicily and at Upsala, while at Altona it was unperceived. These periodical disturbances are so regular in their simultaneity that it

has been suggested that they may be used for determining the difference of longitude between two stations. These disturbances, which were long believed to be casual and irregular, General Sabine found to be apparently governed by the sun's place in the heavens; numerous observations proving that although they may vary locally, both in direction and intensity, the hourly and annual variations at one spot appear to differ in the same ratio as those taken elsewhere. These diurnal and annual variations may be dependent either on the varying heat or place of the sun, or on both, for it is found that the three magnetic elements deviate from their mean annual state, so as to have maximum values in September and April, and minimum in January and June, the aggregate of the maximum values being three times greater than that of the minimum.

On account of the rotation of the earth, the diurnal disturbances, the total force, and consequently the inclination also, deviate from their mean value, and have two maximum values and two minimum in the course of 24 hours, and the declination makes two deviations to the E. and two to the W. from its mean position in the same period. The great disturbances are found to be independent of the meteorological variations going on at the same time.

Throughout the middle latitudes of the N. hemisphere the N. end of the magnet has a mean motion from E to W. from eight in the morning till half past one; it then moves to the E. till evening, after which it makes another excursion to the W., and returns again to its original position at eight in the morning. The extent of its variation is greater in the day than in the night, in summer than in winter. It decreases from the middle latitudes in Europe, where it is 13 or 14 minutes, to the equator, where it is only three or four: but at the equator the variations take place with extreme regularity. The horary motions of the S. end of the magnet in the S. hemisphere are accomplished in an exactly opposite direction. Between the two magnetic hemispheres there is a zone passing through an infinity of places, and very nearly coinciding with the line of minimum magnetic intensity, where the horary phenomena of both hemispheres are combined, each predominating alternately at opposite seasons. At St. Helena, one of the places in question and nearly on the line of minimum intensity, the horary motion of the N. end of the magnet corresponds in direction during one half of the year with the movement in the N. hemisphere, and in the other half of the year the direction at the same hours corresponds with that in the S. hemisphere; the passage from the one to the other being at the equinoxes, when the diurnal variations at the usual hours partake

more or less of the characteristics of both on different days.[1] This variation is owing to the sun's declination, its maxima happening when the sun is in or near the opposite solstices, and disappearing at or near the epochs of the equinoxes.

It had been found that the diurnal variation of each of these magnetic elements was a double progression, having each two maximum and two minimum values in their respective periods. From an attentive observation of the results obtained at the British colonial observatories, General Sabine was led to the belief that the double progression was the effect of two combined or superposed variations which have different hours of maxima and minima, and are occasioned by distinct causes; one being the regular diurnal variation caused by the difference in the sun's position relatively to the place of observation at the different hours of the day and night, and the other being the mean effect of the occasional or casual disturbances. The separation of these two variations, in order to ascertain the distinct laws of the regular solar-diurnal and the casual variations, General Sabine accomplished by the reduction and comparison, according to a method devised by himself, of more than 100,000 observations, and has thereby established the strict periodical character of the magnetic storms and their influence in producing the double maximum and minimum of the diurnal variation. In addition to the annual and diurnal periods which this examination proved to belong to the casual disturbances, it showed also that their frequency and amount in different years gradually and steadily increased from a minimum in the year 1843 to a maximum in 1848, so as to be more than twice as great at the end of that time as at the beginning of it. Thus a variation, having its period nearly 11 years, was clearly established in the casual disturbances of each of the three magnetic elements, and concurrently with this a variation having a similar period and similar epochs of maxima and minima was shown to exist in the solar-diurnal variations of each of the three elements.

This variation is a most important discovery in itself, but becomes much more so from its connexion with the spots on the surface of the sun, first pointed out by General Sabine, which has changed the received opinion as to the cause of the variations in terrestrial magnetism. M. Schwabe had observed with care the

---

[1] At St. Helena the N. end of the needle reaches its E. extreme in May, June, July, and August, and nearly at the same hours it reaches its W. extreme in November, December, January, and February. The passage from one to the other takes place at, or soon after, the equinoxes, in March and April, September and October.—Sabine's Notes to 'Cosmos,' vol. ii.

solar spots during a period of 24 years, and found that they are periodical both in frequency and number, having a regular maximum and minimum every 5 years, the minima being in the years 1833 and 1843, and the maxima in 1838 and 1848; thus exactly coinciding with the period of the decennial variation in the magnetic elements.[1]

There is but little doubt that magnetic storms are induced, or at any rate intensified, by changes in the sun's atmosphere. M. Schwabe's observations have received striking confirmations from various observers. In 1861 Mr. Carrington was attentively watching a large sun spot, a minute point of which suddenly burs out into a brilliant blaze of light; on making inquiries at Kew it was found that a severe magnetic storm took place exactly at the same moment.

A series of observations made on the declination, by Captain Maguire, R.N., at Point Barrow, on the shores of the Polar Sea, prove beyond a doubt that the casual disturbances there are subject to the laws of the solar hours and of the solar spots. There is also a double progression, the principal maximum being at eight in the morning both at Point Barrow and Toronto, and a secondary maximum a little before midnight. When the great disturbances were separated, the solar-diurnal variations appeared to be the same with those at Toronto and throughout the extra-tropical part of the N. hemisphere, the epochs of the extreme easterly and westerly variations being the same at both stations. But, notwithstanding these coincidences, there is a complete antagonism in the disturbance variations at Point Barrow and Toronto, the epochs of the deflections of the needle being nearly opposite to one another at the two stations, so that at nearly the very same hour the disturbance was easterly at the one station and westerly at the other, and *vice versâ*. At the same time a strong analogy was observed to exist between the eastern disturbance deflections at Toronto and the western at Point Barrow, and between the western disturbance deflections at Toronto and the eastern at Point Barrow.

The deflection caused by the occasional disturbances at Point Barrow is very much greater, when compared with the same at Toronto, than can be explained by the difference of the horizontal force of the earth at the two stations. The mean daily effect of the casual disturbances was found to be more than ten times greater at Point Barrow than at Toronto; hence, as it may be greater, equal to, or less than the diurnal solar variation, according to the lati-

[1] In consequence of the action of the planets Venus and Jupiter on the sun's equator the period of the spots is increased to 11⅑ years.

tude, it may occasion a great variety of phenomena in different localities. Besides, the aurora was seen contemporaneously with the observations 1077 times in 6 months, which strikingly accords with the excessive amount of the occasional disturbances at Point Barrow, as it is well known to affect the magnetic needles; but as there were great disturbances when there was no aurora, it cannot be admitted to be the sole cause of the unusually great disturbances at Point Barrow.

Every series of observations shows the universal prevalence of the period in question in the solar magnetic variations. It is a discovery of the highest importance, as it proves that the solar influence on terrestrial magnetism is cosmic, and not thermic, as has been generally believed; and this is confirmed by the action of the moon, which has little heat. M. Kreil, of Milan, first discovered the existence of a lunar diurnal variation in the declination, but since that, the numerical values of the diurnal lunar variations in all the three magnetic elements have been determined at all our colonial observatories, and it was found that these variations presented the same general characters at the three stations. They are not affected by the decennial variation which is found in all the solar inequalities, but yet they follow a double progression, having in each element two maxima and two minima in 24 hours, which constitutes a marked difference between the action of the sun and the moon on terrestrial magnetism.[1]

The discovery of the magnetism of the atmosphere and the effects of the astounding display on August 29 and September 2, 1859, place the aurora unquestionably in the class of electro-magnetic phenomena. The aurora occurs in the N. and S., where the air is highly condensed by cold, and consequently highly magnetic. It generally appears soon after sunset in the form of a luminous arch stretching more or less from E. to W., the most elevated point being frequently in the magnetic meridian of the place of the observer: across the arch the coruscations are rapid, vivid, and of various colours, darting like lightning to the zenith, and at the same time flitting laterally with incessant velocity. The brightness of the rays varies in an instant: they sometimes surpass the splendour of stars of the first magnitude, and often exhibit colours of admirable transparency, blood red at the base, emerald green in the middle, and clear yellow towards their extremity. Sometimes one, and sometimes a quick succession of luminous currents run from one end of the arch or bow to the other, so that the rays

---

[1] M. Lamont, of Munich, has discovered that an electric current is propagated through the surface of the earth parallel to the equator, which is intimately connected with the magnetic variations.

rapidly increase in brightness. The rays occasionally dart far past the zenith, vanish, suddenly reappear, and, being joined by others from the arch, form a magnificent corona or immense dome of light. The segment of the sky below the arch, which rises ordinarily to the height of from 5 to 10 degrees, is quite black, as if formed by dense clouds. Yet this dark segment is not a cloud, for the stars are seen through it as through a dense smoke. M. Struve says 'the stratus that rests on the northern horizon, and appears to be the base of all the auroræ boreales that I have seen for a long time at Dorpat (lat. 58° 21′ N.), is not a cloud, but merely the sky somewhat darkened. Very frequently, when it was quite black, and very high above the horizon, we have seen the stars without any diminution in their brilliancy. Its dark appearance is the effect of contrast with the luminous arc.' This appearance seems to be the result of the presence in the air of condensed vapour in the form of minute spiculæ of ice or flakes of snow. When the aurora covers the whole heavens, the entire atmosphere is filled with the haze caused in this manner, and a dark segment may be observed resting on the southern horizon. The lower edge of the arch is evenly defined; its upper margin is fringed by the streamers which converge by the effect of perspective to the magnetic poles. The apparent convergence of the arch is owing to the same cause.

On the night of the 28th–29th of August, 1859, the most brilliant aurora was seen all over Great Britain, at Brussels, Basel, Rome, and must have been visible in Africa and part of Asia. It was seen over more than the 140° of longitude, from California to Eastern Europe, and from Jamaica to an unknown distance in British America in the N. Intermitting currents of electricity were observed in all the telegraphic wires at Brussels, and the submarine cable from Ostend to Dover remained charged with electricity all the morning of the 29th.

On September 1 and 2 following there was a remarkable coincidence of a simultaneous display of N. and S. auroræ. It was seen at Santiago in Chile, at the Havanna, and almost all over the N. hemisphere; and magnetic disturbances indicated its presence throughout all Northern Asia. An aurora was at the same time seen in South America and New Holland. On September 2, at seven in the morning, the telegraphic communications all over France were greatly affected, and, on interrupting the circuit of the conducting wire at Paris, strong sparks were given out. Similar disturbances were observed in the telegraphic communications in Switzerland; and the aurora on the night of the 2nd was so bright, and its effects so great, in the United States, that the operators were enabled to work the telegraph between Boston

and Portland for two hours without batteries. These remarkable disturbances due to the aurora were currents in the earth from N. to S.; they had that direction at Rome and Leghorn, according to the observations of Padre Secchi and Mr. Maure, as well as in Paris. All showed an increase in the intensity of the vertical component force and a diminution in the horizontal one, with an augmentation in the inclination and declination.

The terrestrial currents, that only appear during the aurora in a decided manner, no doubt always exist permanently and imperceptibly, chiefly in the northern regions, for the discharge between the positive electricity of the atmosphere and the negative electricity of the earth must constantly take place near the pole, with an intensity varying with the season and atmosphere.

The direction of the terrestrial currents ought by theory to be that of the terrestrial meridian, but in the far N. the influence of the terrestrial magnetism makes a deviation in the currents in the atmosphere, which, being perfectly movable, easily obey the action of a foreign force; and that is the reason why the centre of the aurora is in the magnetic pole, and not in the terrestrial. 'Auroras are almost unknown within the tropics. They occur with the greatest frequency in a zone of an oval form which surrounds the N. pole, the central line of which crosses the meridian of Washington in latitude 56°, and the meridian of St. Petersburg in latitude 71°.[1] Accordingly auroras are much more frequent in the United States than they are in the same latitudes of Europe. The form of this auroral zone bears considerable resemblance to a magnetic parallel, or line everywhere perpendicular to a magnetic meridian.' (Loomis's 'Meteorology.')

In Greenland the auroral arch lies to the N. of the observer, and Sir Edward Parry saw it to the S. in Melville Island; consequently it appears in the zenith in some places. From a multitude of observations, it is concluded that the aurora seldom appears at a less elevation than about 45 m. above the earth's surface, and that it frequently extends upwards to an elevation of 500 m. The aurora of August 18, 1859, pervaded more or less the entire interval between the elevations of 46 and 500 m. above the earth's surface. Auroral arcs having a well defined border are generally less than 100 m. in height.

---

[1] Sir George Nares, who passed the winter of 1875–6 on board the 'Alert' in lat. 82° 24′ N. says: 'Light flashes of aurora were occasionally seen on various bearings; but most commonly passing through the zenith. None were of sufficient brilliancy to call for notice. The phenomena may be said to have been insignificant in the extreme, and, as far as we could discover, were totally unconnected with any magnetic or electric disturbance.'

Observations have proved that the disturbances of the magnetic needle and the auroral displays were simultaneous at Toronto, in Canada, on 13 days out of 24, the remaining days having been clouded; and contemporaneous observations show that on these 13 days there were also magnetic disturbances at Prague and at Tasmania, so that the 'occurrence of aurora at Toronto on these occasions may be viewed as a local manifestation connected with magnetic effects, which probably prevailed on the same day over the whole surface of the globe.'[1] At Point Barrow, Captain Maguire, R.N., mentions that during December, January, and February, a time at which there was hardly any daylight, the aurora appeared six days out of every seven for two years, and that it was seen contemporaneously 1077 times with considerable magnetic disturbances; but similar disturbances often occurred without it. It has been observed that the two kinds of auroral action bear a strong analogy to the two modes of magnetic action discovered by Dr. Faraday, the ordinary auroral beams or streamers being parallel to the magnetic meridian, and the auroral arch at right angles to it. Padre Secchi has shown that the aurora is decidedly an electrical phenomenon, that its line coincides very nearly with the isothermal line of zero, and that it must always appear when the atmosphere is full of small needles of ice—conditions which explain the singular action upon the magnetic needle of certain cirrus clouds formed of minute icicles. The auroras of 1859 produced exactly the same effects as currents of electricity. The auroral light is electric light, and its colours are the same as those of ordinary electricity passing through rarefied air. The auroral beams are illumined spaces caused by the flow of electricity through the upper regions of the atmosphere, and are probably the result of currents of electricity travelling in the direction of the axis of the beams. The flashes of light are due to inequalities in the motion of the electric currents through the imperfectly conducting medium, the air.

Auroras, like the solar spots, and the mean daily range of the magnetic needle, exhibit two distinct periods of greatest frequency; one a period of from 10 to 12 years, the other a period of from 58 to 60 years.

There appears to be an increased quantity of ozone in the atmosphere during the auroral apparitions; it was observed to be particularly great on August 29 and September 2, 1859, at Paris.

[1] General Sabine's Notes to the English translation of Humboldt's 'Cosmos,' vol. ii.

CHAPTER XXV.

VEGETATION.

§ 1. **Range of Vegetation on the Earth's Surface.**—In the present state of the globe a third part only of its surface is occupied by land, and probably not more than a fourth part of that is inhabited by man; but animals and vegetables have a wider range. The greater part of the land is clothed with vegetation and inhabited by quadrupeds; the air is peopled with birds and insects; and the sea teems with living creatures and plants. These organised beings are not scattered promiscuously, but all classes of them occupy localities suited to their respective wants. Many animals and plants are indigenous only in determinate spots, while a thousand others might have supported them as well, as is proved by many of them thriving in such places when transported thither by man.

Plants extract from the ground inorganic substances which are indispensable to bring them to maturity, but the atmosphere supplies the vegetable creation with the principal part of its nourishment.

The black or brown mould which is so abundant is the produce of decayed vegetables. When the autumnal leaves, the spoil of the summer, fall to the ground, and their vitality is gone, they slowly decompose and, combining with the oxygen of the atmosphere, an equal volume of carbonic acid is evolved, which is absorbed by the water that exists abundantly in every good soil, and is the most important element in the nourishment of vegetables.

In loosening and refining the soil, as well as in facilitating the burial of dead leaves, and mixing these with the soil, the common earth worm is the fellow labourer with man; it eats earth, and, after extracting the vegetable matter, ejects the refuse, which is the finest soil and may be seen lying in heaps at the mouth of its burrow. So instrumental is this creature in preparing the ground, that it is said there is not a particle of the finer vegetable mould that has not passed through the intestines of a worm: thus the most feeble of living things is employed by Providence to assist man.

The food of the vegetable creation consists of carbon, oxygen, hydrogen, and nitrogen; plants obtain the two former entirely from the atmosphere, the two latter chiefly from the earth, in the form of water and ammonia. After having imbibed and decomposed these substances, they give back the oxygen to the air, and consolidate the carbon, water, and nitrogen into wood, leaves, flowers, and fruit.

The vitality of plants is a chemical process entirely dependent on the sun's light; it is most active in clear sunshine, feeble in the shade, and nearly suspended during the night, when plants, like animals, have their rest.

The atmosphere contains about one three thousandth part of carbonic acid gas; yet that small quantity yields enough of carbon to form the solid mass of all the magnificent forests and plants that clothe the face of the earth, and the supply of that necessary ingredient in the composition of the atmosphere is maintained by the breathing of animals, by fermentation, by volcanoes, by decomposition of animal and vegetable matter, and by combustion. The green parts of plants constantly imbibe carbonic acid in the day: they decompose it, assimilate the carbon, and return the oxygen pure to the atmosphere.

Since the vivifying action of the sun brings about all these changes, a superabundance of oxygen is exhaled by the tropical vegetation under a clear unclouded sky, where the sun's rays are most energetic, and atmospheric moisture most abundant. In the middle and higher latitudes, on the contrary, the supply of oxygen is greatly less. But an equilibrium is established by means of the winds; the tropical currents carrying the excess of oxygen to higher latitudes, to give breath and heat to men and animals. Harmony exists between the animal and vegetable creations; animals consume the oxygen of the atmosphere, which is restored by the exhalation of plants, while plants consume the carbonic acid exhaled by men and animals; the existence of each is thus due to their reciprocal dependence.

When a seed is thrown into the ground, the vital principle of the contained embryo is stimulated by heat and moisture: its radicle, a definite point of the embryo destined for the purpose, elongates and gives off roots, while the plumule ascends and forms the stem and rudimentary leaves. The roots suck up water mixed with carbonic acid from the soil, to be decomposed by the plant which consolidates the carbon. In this stage of their growth, plants derive their whole sustenance from the ground. As soon, however, as the perfect leaves are formed, they absorb and decompose the carbonic acid of the atmosphere, retain the carbon for their food, and give out the oxygen in the day. It appears wonderful that so small a quantity of carbonic acid as exists in the air should suffice to supply the whole vegetation of the world, until we reflect that the total amount in the air is infinitely greater than all that which is fixed in our forests and coal-fields; and that a process of decomposition replaces the waste.

The fluid matter in the soil, containing different substances in solution, is absorbed by the extremities of the roots (in the case of

exogenous plants), ascends to the stem, passes through the woody tissue, forms vessels and cells, dissolving and appropriating various new substances. Proceeding upwards and outwards, this sap reaches the bark and the leaves, where it is exposed to the air and is elaborated by the function of respiration. It then returns, or descends chiefly through the bark, either directly or in a circuitous manner, communicating with the central parts by the medullary rays, depositing various secretions, more especially in the bark, and giving origin to substances which are destined to nourish and form new tissues.[1] The course of the fluids in *endogens* and *acrogens* is not so well determined. Wood, sugar, starch, gum, oils, resins, and acids are formed through the chemical combination of the constituents of the liquid food of plants with the carbon derived from the carbonic acid of the air. It must be observed, however, that these different substances are produced at different stages in the growth of the plant; for example, starch is formed in the roots, stalk, and seed, but it is converted into sugar as the fruit ripens, and the more starch the sweeter the fruit becomes. Most of these new compounds are formed between the flowering of the plant and the ripening of the fruit, and indeed they furnish the materials for the flowers, fruit, and seed.

Ammonia, the third constituent of plants, a product of the decay and putrefaction of animal matter, also enters them by their roots with rain water, and is resolved within them into its constituent elements, hydrogen and nitrogen. The hydrogen aids in forming the wood, acids, and other substances before mentioned; while the nitrogen enters into every part of the plant and forms new compounds; it exists in the blossom, in the fruit before it is ripe, and in the wood, as albumen; it also exists in gluten, which is the albuminoid part of wheat, barley, oats, and all other cerealia, as well as of esculent roots and tubers, &c. Nitrogen exists abundantly in peas, beans, and pulse of every kind, and it enters into the composition of most alimentary vegetable substances; the use of animal manure is to supply plants with this essential article of their food.

The difference of a clear or cloudy sky has an immense effect on vegetation; the ripening of fruit depends upon the serenity of the sky more than on summer temperature alone. The chemical rays of the solar spectrum have most effect not only on the germination of seed, but also on the growing plant. They penetrate the ground, and have a much greater influence on the germination of seeds than ordinary light or darkness. These rays, together with light, are essential to the formation of the colouring matter

---

[1] Balfour's 'Manual of Botany.'

of leaves: they are most active in spring, when they are in very considerable excess as compared with the quantity of light and heat: but as summer advances the reverse takes place; those hot rays, corresponding to the extreme red of the spectrum, which facilitate the flowering and forming of the fruit, become by far the most abundant; and a set of invisible rays, which exist near the point of maximum heat in the solar spectrum, are also most abundant in summer. Mr. Hunt found that the hot rays immediately beyond the visible red destroy the colour of certain leaves; and for that reason the glass of the great palm house at Kew Gardens is tinged pale yellow green, to exclude the scorching rays in question, though it is permeable by the other rays of heat, those of light and the chemical rays.[1]

In spring and summer the oxygen taken in by the plants aids in the formation of oils, acids, and the other parts that contain it; but as soon as autumn comes, the vitality or chemical action of vegetables is weakened, and the oxygen becomes a minister of destruction; it changes the colour of the leaves, and consumes them when they fall.

Although the food which constitutes the mass of plants is derived principally from water and the gases of the atmosphere, solid substances are also requisite for their growth and perfection, and these they obtain from the earth by their roots. The inorganic matters are the alkalis, phosphates, silicates, sulphates, and others.

It has already been mentioned that vegetable acids are found in the juices of all the families of plants. They are generally in combination with one or other of the alkaline substances, as potash, soda, lime, and magnesia, which are as essential to the existence of plants as the carbonic acid by which the vegetable acids are formed. None of the corn tribe can produce perfect seeds unless they have both potash and phosphate of magnesia; nor can they or any of the grasses thrive without silica, which gives the stiffness to straw,

---

[1] The *Solar Spectrum*, or coloured image of the sun, formed by passing a sunbeam through a prism, is composed of a variety of invisible as well as visible rays. The chemical rays are most abundant beyond the violet end of the spectrum, and decrease through the violet, blue, and green, to the yellow, where they cease. The rays of heat are in excess a little beyond the red end, and gradually decrease towards the violet end. Beside these there are two insulated spots at a considerable distance from the red, where the heat is a maximum. Were the rays of heat visible, they would exhibit differences as distinct as the coloured rays, so varied are their properties according to their position in the spectrum. There are also peculiar rays which produce phosphorescence, others whose properties are not quite made out, and probably many undiscovered influences; for time has not yet fully revealed the sublimity of that creation, when God said, 'Let there be light —and there was light.'

to the beard of wheat and barley, to canes, and bamboos ; it is even found in solid lumps in the joints of bamboo, and is known in India by the name of tabashir. To bring the cerealia to perfection, it is indispensable that in their growth they should be supplied with carbonic acid for the plant, silica to give it strength and firmness, and nitrogen for the grain.

Phosphoric acid, combined with an earth or alkali, is found in the ashes of many vegetables, and is essential to them. Pulses contain but little of it, and on that account are less nutritious than the cerealia. The family of the Cruciferæ, as cabbages, turnips, mustard, &c., contain sulphur in addition to the substances common to the growth of all plants ; each particular tribe has its own peculiarities, and requires a combination suited to it.

The perfume of flowers and leaves is owing to a substance of the nature either of volatile oil or wax, and is often carried by the air to a great distance ; in hot climates it is most powerful in the morning and evening. The odour of plants has been perceived many miles from the coasts of various hot and especially dry countries. The variety of perfumes is infinite, and shows the innumerable combinations of which a few simple substances are capable, and the extreme minuteness of the particles of matter.

§ 2. **Sleep of Plants.**—In northern and mean latitudes winter is a time of rest to the greater part of the vegetable world, and in certain tropical climates the vigour of vegetation is suspended during the dry, hot season, to be resumed at the return of the periodical rains. The periodical phenomena of the appearance of the first leaves, the flowering, the ripening of the fruit, and the fall of the leaf, depend upon the annual and diurnal changes of temperature and moisture, and succeed each other with so much harmony and regularity, that were there a sufficient number of observations, lines might be drawn on a globe approximately indicating places where the leaves of certain plants appear simultaneously, and illustrating the other principal phases of vegetation. In places where the same plants flower on the same day, the fruit may ripen at the same period ; it would therefore be interesting to know what relation lines passing through those places would have to one another and to the isothermal lines ; more especially with regard to the plants indispensable to man, since the periodicity of vegetation affects his whole social condition.

Certain plants sleep during the night ; some show it in their leaves, others in their blossom. Some mimosas not only close their leaves at night, but their leaf-stalks droop ; in a clover field not a leaf opens until after sunrise. The common daisy is a familiar instance of a sleeping inflorescence ; it shuts up its ray-flowers in the evening, and opens its white and crimson tipped star, the

'day's eye,' to meet the early beams of the morning sun; when also 'winking mary-buds begin to ope their golden eyes.'

The crocus, tulip, convolvulus, and many others, close their blossoms at different hours towards evening, some to open them again, others never. The ivy-leaved lettuce opens at eight in the morning, and closes for ever at four in the afternoon. Some plants seem to be wide awake all night, and to give out their perfume then only, or at nightfall. Many of the jessamines are most fragrant during the twilight; the Olea fragrans, the Daphne odora, and the night-stock reserve their sweetness for the midnight hour, and the night-flowering Cereus turns night into day. It begins to expand its magnificent sweet scented blossom in the twilight, it is full blown at midnight, and closes, never to open again, with the dawn of day;—these are 'the bats and owls of the vegetable kingdom.'[1]

Many plants brought from warm to temperate climates have become habituated to their new situation, and flourish as if they were natives of the soil; such as have been accustomed to flower and rest at particular seasons change their habits, and adapt themselves to the seasons of the country that has adopted them.

§ 3. **Propagation of Plants, &c.**—Plants are propagated by seeds, offsets, cuttings, and buds; hence they, but more especially trees, have myriads of seats of life, a congeries of vital systems acting in concert, but independently of each other, every one of which might become a new plant.

All the *floral organs* of plants are composed of modified or transformed leaves; a law developed and established by Linnæus, and which has been since popularised by the illustrious poet Göthe. According to this law, embryo leaves have been found passing into common leaves, these into bracts, bracts into sepals, sepals into petals, these into stamens, and lastly stamens into pistils, which contain the ovules. These changes are not indeed all traceable on any one plant, though several of the series may be (as from sepals to petals and stamens in the white water-lily); but all double flowers, and other so called monsters, afford examples of it; in many of which a sudden change of one of the series into ordinary leaves is common. The double rose is easily seen to be a single

[1] Dandelion opens at five or six in the morning, and shuts at nine in the evening; the goat's beard wakes at three in the morning, and shuts at five or six in the afternoon. The orange coloured Eschscholtzia is so sensitive that it closes during the passage of a cloud. 'The marigold that goes to bed wi' the sun, and with him rises weeping,' with many more, are instances of the sleep of plants: the gentianella, veronica, and other plants close their blossoms on the approach of rain.

rose with the stamens turned into petals; and the sepals to be modified stem-leaves.

§ 4. **Classification of Plants, &c.**—Plants are naturally distributed in two great sub-kingdoms—the *flowering plants*, the flowers of which, containing stamens and pistils, are all formed of whorls of modified leaves, and whose young seeds, called ovules, are fertilised by the pollen of the stamens; and *flowerless plants*, as ferns, mosses, lichens, seaweeds, and fungi, the extremely minute seeds of which are of a very different nature, and which have no flowers properly so called. The flowering plants are divided into two principal classes, called *monocotyledons* and *dicotyledons*; of these the *monocotyledons* grow from within, the foot stalks of the old leaves always forming the outside of the stem; their leaves have parallel veins; the parts of their floral whorls are usually in threes or sixes, and their embryo has but one seed lobe or cotyledon: to this class palms, grasses, lilies, &c., belong. The *dicotyledons* have leaves with netted veins; stems with distinct bark; layers of wood and pith; the parts of their floral whorls are in fours or fives, and the embryo has two seed lobes. All British trees and woody plants belong to this class, which is by far the larger of the two.

These classes are *distributed* in very different proportions in *different zones.* Between the tropics there are four dicotyledons to one monocotyledon, in the temperate zone six to one, and in the polar regions only two to one. In the temperate zones one sixth of the flowering plants are annuals, in the torrid zone scarcely one plant in twenty is annual, and in the polar regions only one in thirty. The number of woody plants increases on approaching the equator. In North America there are 120 different species of forest trees, whereas in the same latitudes in Europe there are only 34.

Equinoctial America has a more extensive vegetation than any other part of the world of equal area; Europe has not above half the number of indigenous species of plants; Asia, with its islands, has far more than Europe. In a memoir on the geographical distribution of plants in Armenia and Asia Minor, M. Pierre de Tchihatchef mentions that no country of its size has such an abundant and varied flora as the latter; that the plants on five mountains only amount to double the entire number of British species. Australia, with its islands, is estimated to possess as many vegetable species as Europe; but new fertile regions are continually being discovered, and the enormous extent of unknown country teeming with vegetation, traversed by Dr. Livingstone, Captains Burton and Speke, M. du Chaillu, Lieut. Cameron, and others in

tropical Africa, renders any estimation of the botanical riches of that continent impossible at present.

Since the constitution of the atmosphere is very much the same everywhere, vegetation depends principally on the sun's light, moisture, and the mean annual temperature, and it is also in some degree regulated by the heat of summer in the temperate zones, and also by exposure, for such plants as require warmth are found at a higher level on the S. than on the N. side of a mountain, in the N. hemisphere. Between the tropics, wherever rain does not fall, the soil is burnt up, and is as unfruitful as that exposed to the utmost rigour of frost; but where moisture is combined with heat and light the luxuriance of the vegetation is beyond description. The abundance and violence of the periodical rains combine with the intense light and heat to render the tropical forests and jungles almost impervious from the rankness of the vegetation. This exuberance gradually decreases with the distance from the tropics; it also diminishes progressively as the height above the level of the sea increases, so that each height has a corresponding parallel of latitude where the climates and floras are analogous; and at the regions near the line of perpetual snow the vegetation scarcely rises above the surface of the ground, and presents a counterpart to that of the polar regions. Hence, in ascending the Himalayas or Andes from the luxuriant bases of those mountains, changes take place in the vegetation analogous to what a traveller would meet with in a journey from the equator to the poles. This law of decrease, though perfectly regular over a wide extent, is perpetually interfered with by local circumstances. From various causes, as the distribution of land and water, their different powers of absorption and radiation, together with the form, composition, and clothing of the land, and the prevailing winds, it is found that the *isothermal lines* do not correspond with the parallels of latitude. Thus, in North America the climate is much colder than in the corresponding European latitudes. Quebec is in the latitude of Paris, and the country is covered with deep snow four or five months in the year, and a summer has been experienced there in which not more than 60 days had been free from frost. In the S. hemisphere, beyond the 34th parallel, the summers are colder and the winters milder than in corresponding latitudes of the N. hemisphere.

Neither does the temperature of mountains always vary exactly with their height above the sea; other causes, as prevailing winds, difference of radiation, and geological structure, concur in producing irregularities, which have a powerful effect on the vegetable world.

However, no similarity of existing circumstances can account for whole families of plants being confined to one particular country,

or even to a very limited district, which, as far as we can judge, might have grown equally well on many others. Latitude, elevation, soil, and climate, are but secondary causes in the distribution of the vegetable kingdom, and are totally inadequate to explain why there are numerous distinct botanical districts, each of which has its own vegetation, the limits of which are most decided when they are separated by the ocean, mountain chains, sandy deserts, salt plains, or inland seas. Each of these districts is the focus of families and genera, some of which are found nowhere else, and some of which are common to others.[1]

As the land rose at different periods above the ocean, each part as it emerged from the waves was probably clothed with vegetation, and peopled with animals, suited to its position and climate. And as the conditions and climate were different at each succeeding geological epoch, so each portion of the land, as it emerged from the ocean, would be characterised by its own vegetation and animals; and thus many centres of creation would result, all differing more or less from one another, and hence alpine floras must be of older date than those in the plains. The vegetation and faunas of those lands that differed most in age and place would be most dissimilar, while the plants and animals of such as were not far removed from one another in time and place would have correlative forms or family likenesses; yet each region would form a distinct province. During these changes the older forms may have been modified to a certain extent by the succeeding conditions of the globe.

The flora of the higher parts of the Himalayas is to some extent similar to that of Europe, many species being identical. In the mountains and valleys of Tibet, where the cold is not less than in the wastes of Siberia, the vegetation of one might be

[1] Professor Schouw divided the earth's surface into 25 botanical regions; and Professor Martius, of Munich, into 51 provinces, namely, 5 in Europe, 11 in Africa, 13 in Asia, 3 in Australia, 4 in North and 8 in South America, besides Central America, the Antilles, the Antarctic Lands, New Zealand, Tasmania, New Guinea, and Polynesia. To these, other divisions might be added, as the Galapagos, the flora of which is so strongly defined.

Baron Humboldt gives the following concise view of the distribution of plants, as to height:—

The equatorial zone is the region of palms and bananas.
The tropical zone is the region of tree-ferns and figs.
The subtropical zone, that of myrtles and laurels.
The warm temperate zone, that of evergreen trees.
The cold temperate zone, that of European or deciduous trees.
The subarctic zone, that of conifers.
The arctic zone that of rhododendrons.
The polar zone, that of alpine herbs.

mistaken for that of the other; the gooseberry, currant, rhubarb, tamarisk, willow, and poplar, growing in both. The flora near the snow line on the lofty mountains of Europe has also a perfect family likeness to that of high northern latitudes. In like manner many plants on the higher parts of the Chilian Andes are similar to those in Tierra del Fuego, and even identical with them; nay, the Arctic flora has a certain resemblance to the Antarctic, and presents even identical species.

In the many vicissitudes the surface of the globe has undergone, continents formed at one period were at another broken up into islands and detached masses by inroads of the sea, and other causes. Professor E. Forbes has shown that some of the primary floras and faunas have spread widely from their original centres over large portions of those continents before the land was broken up into the form it now has, and he thus accounts for the similarity and sometimes identity of the plants and animals of regions now separated by seas—as, for example, islands, which generally partake of the vegetation and fauna of the continents adjacent to them. Taking for granted the original creation of specific centres of plants and animals, Professor E. Forbes has clearly proved that 'the specific identity, to any extent, of the flora and fauna of one area, with those of another, depends on both areas forming, or having formed, part of the same specific centre, or on their having derived their animal and vegetable population by transmission, through migration, over continuous or closely contiguous land, aided, in the case of alpine floras, by transportation on floating masses of ice.'

Comparatively very few of the exogenous or dicotyledonous plants are common to two or more countries far apart. There are many more instances of wide diffusion among the monocotyledonous plants, especially grasses. The aquatic monocotyledonous plants offer perhaps more striking examples of wide diffusion over the surface of the globe than any other, whilst the cellular or cryptogamous class is the most widely diffused of all.

In islands far from continents the number of plants is small, but of these a large proportion occur nowhere else. In St. Helena, of 30 flower bearing plants, one or two only are native elsewhere, but of 60 species of cryptogamous plants Dr. Hooker found only 12 peculiar to the island.

Plants are *dispersed* by currents: of 600 plants from the vicinity of the River Congo on the coast of Africa, 13 are also found on the shores of Guiana and Brazil, evidently carried by the great equatorial current to countries congenial in soil and climate. The seeds of the Entada scandens, the Guilandina Bonduc, and the cashew nut, are wafted from the West Indian Islands, by the Gulf Stream,

to the coasts of Scotland and Ireland, where the climate and soil do not suit them, and where therefore they do not become naturalised, though some are stated to have vegetated. *Winds* also waft seeds to great distances; *birds* and *quadrupeds*, and above all *man*, are active agents in dispersing plants. Plants introduced by man into other than their native countries frequently become quasi-indigenous; for example, the Argemone Mexicana, stated to have been introduced into India from Mexico about three centuries ago, is now abundant in a wild state in many parts of India.

CHAPTER XXVI.

VEGETATION—*continued.*

§ 1. **Vegetation of the Great Continents.**—The southern limit of the polar flora, on the old continent, lies mostly within the Arctic Circle, but stretches along the tops of the Scandinavian mountains, and reappears in the high lands of Scotland, Cumberland, and Ireland, on the summits of the Pyrenees, Alps, and other mountains in southern Europe, as well as on the mountains of central Asia, and on the high ridges of the Himalayas.

The great European plain extending to the Ural Mountains, as well as the low lands of England and Ireland, were at one period covered by a sea full of floating ice and icebergs, which made the climate much colder than it now is. At the beginning of that period the Scandinavian range, the other continental mountains, and those in Britain and Ireland, were islands of no great elevation, and were then clothed with the present Arctic flora, representatives of which they still retain now that they form the tops of the mountain chains. At that time both plants and animals were conveyed from one country to another by floating ice. It is even probable, from the relations of their fauna and flora, that Greenland, Iceland, and the very high European latitudes, are portions of a great northern land which had for the most part sunk down at the close of the glacial period, for there were many vicissitudes of level during that epoch. At all events, it may be presumed that the elevation of the Arctic regions of both continents, if not contemporaneous, was probably not far removed in time. Similarity of circumstances had extended throughout the whole Arctic regions, since there is a remarkable similarity and even identity of species of plants and animals in the high latitudes of both continents, which is continued along the tops of their mountain chains,

even in the temperate zones; and there is reason to believe that the relations between the faunas and floras of North America, Asia, and Europe, must have been established towards the close of the glacial period.

The plants of Iceland are almost wholly identical with those of Britain, yet only one in four of the British plants are known in Iceland. There are 870 species in Iceland, of which more than half are flower bearing. This flora is scattered in groups according as the plants like a dry, marshy, volcanic, or marine soil. Many grow close to the hot springs; some not far from the edge of the basin of the Great Geyser; and species of Confervæ flourish in a spring said to be almost hot enough to boil an egg. The Cerealia cannot be cultivated on account of the severity of the climate, but the Icelanders make bread from *metur*, a species of wild corn, and also from the bulbous root of Polygonum viviparum; their greatest delicacy is the Angelica Archangelica; Iceland moss, used in medicine, is an article of commerce. There are 583 species in the Faröe Islands, of which 270 are flowering plants: many thrive there that cannot bear the cold of Iceland.

§ 2. **Arctic and Colder Temperate Flora of the Great Continents.**—In the most N. parts of the Arctic lands the year is divided into one long intensely cold night and one bright and fervid day, which quickly brings to maturity the scanty vegetation. Within the limit of perpetual congelation the Protococcus nivalis (or red snow of the Arctic voyagers), which consists of an excessively thin stratum of microscopic red or orange coloured globules, finds nourishment in the snow itself, the first dawn of vegetable life; it is also found colouring large patches of snow on the Alps and Pyrenees.

Lichens are the first vegetables that appear at the limits of the snow line, whether in high latitudes or mountain tops, and they are the first vegetation that takes possession of volcanic lavas and new islands, where they prepare soil for plants of a higher order; they grow on rocks, stones, and trees, in fact on anything that affords them moisture. Many species are known; no plants are more widely diffused, and none afford a more striking instance of the power of migration possessed by species, as they are of so little direct use to man that they have not been disseminated by his agency. The same kinds prevail throughout the Arctic regions, and species common to both hemispheres are very numerous. Some lichens produce brilliant red, orange, and brown dyes; and the *tripe de roche*, of the North American hunters, is a miserable substitute for food, as our intrepid countryman Sir John Franklin and his brave companions experienced in their perilous Arctic journeys.

Mosses follow lichens on newly formed soil, and they are found

everywhere throughout the world in damp situations, but in greatest abundance in temperate and alpine climates. Upwards of 1000 species are known, of which a considerable number inhabit the Arctic regions, constituting a large portion of the vegetation.

In Asiatic Siberia, N. of the 60th parallel of latitude, the ground is perpetually frozen at a very small depth below the surface: a temperature of the air of $-70°$ Fahr. is not uncommon, and in some instances the cold has been $-120°$. Then it is fatal to animal life, especially if accompanied by wind. In some places trees grow and corn ripens even at 70° N. lat.; but in the most northern parts, boundless swamps, varied by lakes both of salt and fresh water, cover wide portions of this desolate country, which is buried under snow nine or ten months in the year. As soon as the snow is melted by the returning sun these extensive morasses are covered with coarse grass, sedges, and rushes, while mosses and lichens, mixed with dwarf willows, clothe the plains.

In Novaia Zemlia and other places in the far north the vegetation is so stunted that it barely covers the ground, but a much greater variety of minute plants of considerable beauty are crowded together there in a small space than in the Alpine regions of Europe, where the same genera grow. This arises from the diminutive size of the vegetation; for in the Swiss Alps the same plants frequently occupy a large space, excluding every other species. In the remote north, on the contrary, where vitality is comparatively feeble and the seeds do not ripen, 30 different species may be seen crowded together in a bright green mass, no one having strength to overcome the rest. In such frozen climates plants may be said to live between the air and the earth, for they scarcely rise above the soil, and their roots creep along the surface, having scarcely power to enter it. All the woody plants, as the Betula nana, the reticulate leaved willow, Andromeda tetragona, with a few berry-bearing shrubs, trail along the ground, never rising more than an inch or two above it. The Salix lanata, the giant of these Arctic forests, never grows more than 5 inches high, while its stem, 10 or 12 ft. long, lies hidden among the moss, owing shelter to its lowly neighbours.

The chief characteristic of the vegetation of the Arctic regions is the predominance of perennial and cryptogamous plants, and also the sameness of its nature; but more to the S., where night begins to alternate with day, a difference of species appears. A beautiful flora adorns these latitudes during their brief but bright and ardent summer, consisting of potentillas, gentians, chickweeds, saxifrages, sedums, ranunculi, drabas, artemisias, claytonias, and many more. Such is the power of the sun, and the consequent rapidity of vegetation, that these plants spring up, blossom, ripen their seed, and die

in a few weeks: in a lower latitude woody plants follow these, as berry-bearing shrubs, the glaucous kalmia, the trailing azalea, and rhododendrons.

A large proportion of the plants found by Wormskiold in Kamtschatka are European, intermixed with many which are purely American. Few European trees grow in Asiatic Siberia, notwithstanding the similarity of climate, and most of them disappear towards the Rivers Tobol and Irtish.

In Lapland and in the high latitudes of Russia large tracts are covered with birch trees, but the pine and fir tribe are the principal inhabitants of the N. Prodigious forests of these are spread over the mountains of Norway and Sweden, and in European Russia 200,000,000 acres are clothed with these Coniferæ alone, occasionally mixed with willows, poplars, and alders. Although tracts of pure sand and limestone are absolutely barren, yet the soil generally contains enough of alkali to supply the wants of the fir and pine tribe, which require ten times less than oaks and other deciduous trees.

Social plants abound in many parts of the N. temperate regions, as grass, heath, furze, and broom; the steppes are an example of this on a very extensive scale. Both in Europe and Asia they are subject to a rigorous winter, with deep snow and chilling blasts of wind: and as the soil generally consists of a coating of vegetable mould over clay, no plants with deep roots thrive upon them; hence the steppes are destitute of trees, and even bushes are rare except in ravines; the grass is thin, but nourishing. Hyacinths and some other bulbs, mignonette, asparagus, liquorice, and wormwood, grow in the European steppes; the two latter are peculiarly characteristic.

Each steppe in Siberia has its own association of plants; the Peplis and Camphorosma are peculiar to the steppe of the Irtish, and the Amaryllis tartarica abounds in the meadows of E. Siberia, the vegetation of which bears a great analogy to that of America, many genera and species being common to both.

The Siberian steppes are bounded on the S. by great forests of pine, birch, and willow; poplars, elms, and Tartarian maple overhang the upper courses of the noble rivers which flow from the mountains to the Frozen Ocean; and on the banks of the Yenisei the Pinus Cembra, or Siberian pine, with edible seeds, grows 120 ft. high. The Altaï are covered in some parts nearly to their summits with similar forests, but on their greatest heights the stunted larch crawls on the ground, and the flora is like that of N. Siberia: round Lake Baikal the Pinus Cembra grows nearly to the snow line.

Forests of black birch are peculiar to Dauria, where there are

also apricot and apple trees, and rhododendrons, of which a species with yellow blossoms grows in thickets on the hills. Here and everywhere else throughout Central Asia are found various species of Caragana, a genus eminently Siberian.

The elevated mountain mass of Tibet has the character of great sterility, and the climate is as unpropitious as the soil: frost begins early in September, and continues with little interruption till May; snow, indeed, in some parts, falls every month in the year, though in excessively small quantities, owing to the extreme dryness of the climate. The air is always dry, because moisture falls chiefly in winter, in the form of snow, and in summer it is quickly evaporated by the intense heat of the sun. The thermometer sometimes rises to 144° Fahr., and even in winter the direct rays of the sun have great power for an hour or two, so that a variation of 100° in the temperature of the air has occurred in 12 hours. Notwithstanding these disadvantages, there are sheltered spots, heated by radiation from the dry rocky mountain flanks, which produce most of the European grains and fruits, the vegetation being of Siberian character, and the species to a considerable extent identical. The most common indigenous plants are Tartarian furze (Caragana), and various prickly shrubs resembling it—gooseberries, currants, hyssop, dog rose, dwarf sow thistle, and rhubarb. Prangos, an umbelliferous plant, with abundant foliage, is peculiar to Ladak and parts of Tibet. Mr. Moorcroft says it is so nutritious that sheep fed on it become fat in twenty days. There are three varieties of wheat, three of barley, and two of buckwheat cultivated, as also are maize and rice together with pulses, lucerne, lentils, and spinach. Olives, pears, apples, peaches, apricots, mulberries, grapes, currants, and melons of large size and delicious flavour are produced. Cotton of valuable quality abounds, and plants on which silkworms are fed. Owing to the rudeness of the climate, trees are not numerous, yet on the lower declivities of some mountains there are poplars, birch, walnut, willows, juniper, hippophaë, and Gerard's pine, the nuts of which are eaten.

The great valley of Tartary N. of Tibet is chiefly occupied by the Gobi and other deserts of sand, with chains of salt lakes, and grassy steppes near the mountains. In all parts of these Mongolian deserts vegetation depends chiefly on the rains. Directly these have fallen and the influence of the sun begins to be felt, young plants shoot up with surprising rapidity and the deserts are sprinkled with green oases. But all this new life is of the briefest duration; for as soon as the scorching sun has evaporated the moisture the herbage withers, and all becomes again a scene of sterile desolation. The most common flora of these deserts is the *karmyk*, a saline shrub which grows in stunted clumps and is much

valued for its berries; the *budarhana* (kalidium gracilis), a saline shrub which forms the favourite food of the camel; *scrub wormwood*; *onion*; *dirisun*, a wiry kind of grass which grows in clumps from 4 to 5 ft. high; and a few other of the *graminæ*.[1]

§ 3. **Flora of Britain and of Middle and Southern Europe.**—The British Islands afford an excellent illustration of distinct provinces of animals and plants, and also of their migration from other centres. Professor E. Forbes has adopted five botanical districts, the plants of four of which are restricted to limited provinces, whilst those of the fifth, which comprehends the great mass of British plants, are everywhere. All of these, with a very few doubtful exceptions, had migrated into the British Islands before the latter were separated from the continent. The first flora, which is of great antiquity, includes that of the mountain districts of the W. and S.W. of Ireland, and is similar to that of the N. and W. of Spain. The second flora is that of the S. of England and the S.E. of Ireland, which is different from that in all other parts of the British Islands; it is intimately related to the vegetation of the Channel Islands and the coast of France opposite to them. The third flora appears in the S.W. of England, where the chalk plants prevail, and the flora is like that on the adjacent coast of France.

The tops of the loftiest British mountains form the fourth class, and are the focus of a separate flora, which is the same with that in the Scandinavian Alps, and is very numerous. Scotland, Wales, and a part of Ireland received this flora when they were groups of islands in the Glacial Sea, and some few individuals grow on the summits of the mountains in Cumberland. The rare Eriocaulon is found in the Hebrides, in Connemara, and in North America, and nowhere else. The fifth, of more recent origin than the alpine flora, includes all the ordinary flowering plants, as the common daisy and primrose, hairy ladies' smock, upright meadow crowfoot, and the lesser celandine, together with our common trees and shrubs; it migrated from Germany at a later epoch, but still before England was separated from the continent of Europe by the British Channel. It can be distinctly traced in its progress across the island, but the migration was not completed till after Ireland was separated from England by the Irish Channel. This is the reason why many of the ordinary English plants, mammals, and reptiles are not found in the sister island, for the migration of animals was simultaneous with that of plants, and took place between the last of the tertiary periods and the historical epoch. This flora extends also over a great part of the continent.

[1] See Col. Prejevalsky's 'Mongolia,' chaps. i. and viii.

Deciduous trees are the chief characteristic of the temperate zone of the whole continent, more especially of middle Europe. Oaks, elms, beech, ash, larch, maple, lime, alder, and sycamore, all of which lose their leaves in winter, are the prevailing trees, occasionally mixed with social pines and firs, together with grass pastures and extensive heaths in some places.

Evergreen trees and shrubs, with shining leaves, become more frequent in the S. of Europe, where about a fourth part of the woody plants never entirely lose their leaves. The trees and shrubs consist chiefly of evergreen oaks, cypress, hornbeam, sweet chestnut, laurel, laurustinus, walnut, maple, manna or the flowering ash, carob, jujube, juniper, pistachios (some of which yield oily nuts, some resin, and some mastic), arbutus, myrtle, jessamine and various pines, as the Pinus maritima, and Pinus pinea, or stone pine, which forms so picturesque a feature in the landscape of S. Europe. The most prevalent herbaceous plants are Compositæ, Grasses, and Caryophyllaceæ, as Pinks, Stellaria, and Arenarias; and also the labiate tribe, mint, thyme, rosemary, lavender, with many others, all remarkable for their aromatic properties and their love of dry situations. Many of the choicest plants and flowers which adorn the gardens and grounds in northern Europe are indigenous in these warmer countries: the anemone, mignonette, narcissus, gladiolus, iris, asphodel, amaryllis, carnation, &c. In Spain, Portugal, Sicily, and on the other European shores of the Mediterranean, tropical families begin to appear in the Aroideæ, plants yielding balsams, oleander, date and palmetto palms, and grasses of the group of Panicum or millet, aloes, and cactus. In this zone of transition there are six herbaceous for one woody plant.

§ 4. **Flora of Temperate Asia.**—The vegetation of W. Asia approaches to that of W. India at one extremity and N. Africa and E. Europe at the other. Syria and Asia Minor form a region of transition, like the other countries on the Mediterranean, where the plants of the temperate and tropical zones are united. We owe many of our best fruits and sweetest flowers to these regions. The cherry, almond, oleander, syringa, locust tree, &c., come from Asia Minor; the walnut, peach, melon, cucumber, hyacinth, ranunculus, come from Persia; the date palm, fig, olive, mulberry, and damask rose, come from Syria; the vine and apricot are Armenian; the latter is cultivated everywhere in middle and northern Asia. The tropical forms met with in more sheltered places are the sugar cane, date, and palmetto palms, acacias, Asclepias gigantea, and arborescent Apocynaceæ. The singular gorge of the Jordan valley presents a tropical vegetation. The papyrus, now extinct in Egypt, is found in the marshes of Merom; and the Zizyphus

spinachristi is characteristic of the whole course of the river. The 'Zukkum,' or false balm of Gilead, the osher tree of Nubia and Abyssinia, the henna or camphire, and the Salvidora Persica abound. The flowers are of Abyssinian, S. Arabian, and some of Indian types.[1] The Nelumbium speciosum grows in one spot 5 miles from the town of Astrakhan, and nowhere else in the wide domains of Russia; the leaves of this beautiful aquatic plant are often two feet broad, and its rose-coloured flowers are very fragrant. It is also a native of India, where it is held sacred, as it was formerly in Egypt, where it is said to be extinct: it is one of the many instances of a plant growing in countries far apart.

The plains of Persia are covered with a clayey, sandy, or saline soil, and the climate is very dry; hence vegetation is poor, and consists of thorny bushes, acacias, tamarisk, jujube, &c. Forests of oak cover the mountains of Laristan, but the date palm is almost the only arborescent produce of the parched shores of the Arabian Gulf and of the oases on the Persian plains. In the valleys, which are beautiful, there are clumps of Oriental plane and other trees, hawthorn, tree roses, and many of the odoriferous shrubs of Arabia Felix.

Afghanistan produces in its valleys the seedless pomegranate, acacias, date palms, tamarisks, &c. The valleys of the Hindu Kush present clover, thyme, violets, and many odoriferous plants; the greater part of the trees in the mountains are of European genera.

Hot, arid deserts bound India on the W., where the stunted and scorched vegetation consists of tamarisks, thorny acacia, deformed Euphorbiæ, and almost leafless thorny trees. Indian forms begin to abound east of the Indus, but Syrian and Persian genera and species accompany these as far east as Delhi.

The Himalaya Mountains form a distinct botanical district. Immediately below the snow line the flora consists of Arctic, Siberian, Alpine, European, and Caucasian forms, amongst which rhododendrons and andromedas are conspicuous. Lower down European forms become universal, though the species are Indian. There are extensive forests of Coniferæ, consisting chiefly of Pinus excelsa, Pinus deodara, and Smithiana, with many deciduous forest and fruit trees of European genera. Here the scarlet and other rhododendrons grow luxuriantly; walnuts, numerous species of oak, many of which attain a great size, and maples. A transition from this flora to a tropical vegetation takes place between the altitudes of 4000 and 6000 ft. On the hot declivities of the mountains, tropical types, as Erythrina and Bombax heptaphyllum, are common trees, together with the Sal-tree (*Shorea robusta*), Dalbergia and

[1] Tristram's 'Natural History of the Bible.'

Cedrela, a genus allied to mahogany. The flora of the Panjab is greatly modified by the circumstances of the increase of cold going northward or upwards in the hills, and also of the greater aridity towards the W. and towards the interior of the hills. Distance from the hills also increases aridity, and the most arid part of the plains of the Panjab is probably near, and to the W. of, Multán, where the scant rainfall is reckoned by fractions of an inch. The aridity lessens the amount of the vegetation, and modifies its nature. In passing from the outer and middle ranges of the Himalayas into the semi-Tibetan tracts of the Upper Sutlej and Upper Chenáb, this is very evident; and in Ladák, where great elevation is added to intense dryness, trees are almost unknown and shrubs rare, the herbaceous plants are widely different from those growing in the outer hills. Ferns, orchids, and balsams are extremely rare in the Panjab.

It is remarkable that Indian, European, American, and Chinese forms are united in the above mentioned zone of transition, though the distinctness of species still obtains: the Triosteum, a genus of the honeysuckle tribe, is American; the Abelia, another genus of the same tribe, together with Camellia and others, are peculiarly Chinese: the wild thyme is European.

The temperate regions of E. Asia, including Mongolia and Mandchuria, N. China, and Japan, have a vegetation totally different from that of any other part of the globe similarly situated, but closely allied to the temperate Himalayan, and show in a strong point of view the distinct character which vegetation assumes in different longitudes. In Mandchuria and the vast mountain chains that slope from the E. extremity of the high Tartarian table-land to the fertile plains in China, the plants are generally of European genera, but Asiatic species; in these countries the buckthorn and honeysuckle tribes are so numerous as to give a peculiar character to the vegetation. Mixed with these and with roses are thickets of azaleas covered with blossoms of dazzling brightness and beauty.

The transition zone in this country lies between the 35° and 27° N. lat., in which the tropical flora is mixed with that of the N. provinces. The prevailing plants on the Chinese low grounds are Glycine, Hydrangea, the camphor laurel, Stillingia sebifera, or wax tree, Clerodendron, Hibiscus rosa-sinensis, Thuja orientalis, Olea fragrans, the sweet blossoms of which are mixed with the finer teas to give them flavour; Melia azedarach, or Indian pride, the paper mulberry, and others of the genus, and Camellia

[1] Stewart's ‘Panjab Plants.’

sasanqua, which covers hills in the province of Kiang-si. The tea plant and other species of Camellia grow in many parts; the finest tea is the produce of a low range of hills between the 33rd and 25th parallels, an offset from the great chain of Peling.[1]

The climate of S. Japan is milder than its latitude would indicate, owing to the influence of the surrounding ocean. European forms prevail in the high lands, as they do generally throughout the mountains of Asia and the Indian Archipelago, with a difference of species. The Japanese flora is similar to the Chinese, and contains numerous American plants, besides others of Indian and tropical climates. These islands, nevertheless, have their own peculiar flora. Many tropical plants mingle with the vegetation of the Southern Islands.

---

[1] *Thea viridis* and *bohea* are possibly only varieties of the same plant; the black tea is a more robust, the green a more delicate plant. The quality of the tea depends upon the stage of growth at which it is gathered; early leaves make the best tea; those picked late in the season give a very coarse tea. Bohea grows in the province of Fo-kien, hyson in Song-lo. Pekoe, or pak-ho (= 'white down'), consists of the first downy sprouts or leaf-buds of three-years-old plants. A very costly tea of this kind, never brought to Europe, and known as the tea of the Wells or the Dragon, is used only by persons of the highest rank in China. The true Imperial tea also, called *Flos theæ*—which is not, as was supposed, the flower-buds, but merely a very superior quality of tea—seldom reaches Europe; that sold under this name is really Chusan tea flavoured with blossoms of Olea fragrans. The Chinese keep tea a year before they use it, because fresh tea has an intoxicating quality which produces disturbance of the nervous system. It is a remarkable circumstance that tea and coffee, belonging to different families, natives of different quarters of the globe, should possess the same principle—theine and caffeine are in most respects identical—and it is not less remarkable that their application to the same use should have been so early discovered by man. Tea was first brought to Europe by the Dutch in 1610; a small quantity came to England in 1666, and now the annual consumption of tea in Great Britain is upwards of 130,000,000 of pounds.— Davis's 'China.'

The tea plant grows naturally in Japan and Upper Assam: it is hardy and possesses great power of adaptation to climate. It has lately been cultivated in Brazil and in Algiers, at an expense which renders it unprofitable; but it is already very remunerative in Assam and throughout the Himalayas, especially in the Kangra valley, in the upper part of the basin of the Bias. Tea comes to Europe almost exclusively from China, but the plant thrives so well in the N.W. provinces of India that the English will ultimately compete with the Chinese in producing it especially for the Tibet market. In 1869, Mr. Shaw penetrated to Yarkand, carrying Kangra tea.

The plants with which the Chinese give flavour to tea are the Olea fragrans, Chloranthus inconspicuus, Gardenia florida, Aglaia odorata, Jasminum sambac, Vitex spicata, Camellia sasanqua and odorifera, Illicium anisatum, Magnolia yulan, Rosa indica, turmeric, oil of Bixa orellana, and the root of the Florentine iris.

CHAPTER XXVII.

VEGETATION—*continued.*

§ 1. **Flora of the Indo-Chinese Peninsula and the Indian Archipelago.**—Tropical Asia is divided by nature into three distinct botanical regions: the Malayan peninsula, with the Indian Archipelago; India S. of the Himalaya, with the Island of Ceylon; and the Arabian peninsula. The two former have strong points of resemblance, though their floras are peculiar.

Many of the vegetable productions of the peninsula beyond the Ganges are the same with those of other parts of India, mixed with the plants of the Indian Archipelago, so that this country is a region of transition, though it has also a splendid vegetation of peculiar productions, dyes of the most vivid hues, spices, medicinal plants, and many with the sweetest perfume. The soil in many places yields three crops in the year: the fruits of India, and most of those of China, come to perfection in the low lands. Various palms adorn the Malayan peninsula: of these the Arang is eminently characteristic of that country; it is an ugly plant, the stem of which is covered with black fibres like horsehair, sufficiently strong to make cordage. It is cultivated for the sugar and wine made from its juice. Teak is plentiful; almost all that is used in Bengal comes from the Birman Empire, though it is less durable than that of the Malabar coast. The Hopea odorata is so large that a canoe is made of a single trunk; the Gordonia integrifolia is held in such veneration that every Birman house has a beam of it.

There are many species of native oak in the forests: the Mimosa catechu, which furnishes the terra japonica; the trees which produce varnish and stick-lac; the Glyphyria nitida, a myrtle, the leaves of which are used as tea in Bencoolen, called by the natives the tree of long life. The coasts are wooded by mangroves, casuarina, and the Heritiera robusta, a large tree which thrives within reach of the tide; bamboos with stems a foot and a half in diameter grow in dense thickets in the low lands. The Palmyra palm and the Borassus flabelliformis grow in extensive groves in the valley of the Irawadi; the latter is a magnificent tree, often 100 ft. high, remarkable for its gigantic leaves, one of which would shelter 12 men.

The anomalous family of the Cycadeæ, somewhat like palms with large pinnated leaves, is found here and in tropical India. Orchidaceæ and tree ferns are innumerable in the woody districts of the peninsula.

The vegetation of the Indian archipelago is gorgeous beyond description; although it bears a strong affinity to that of the Malayan peninsula, tropical India, and Ceylon. The height of the mountains causes variety in the temperature sufficient to admit of the growth of dammar pines, oaks, rhododendrons, magnolias, maples, honeysuckles, vacciniums, and other European orders of woody and herbaceous plants: yet they have scarcely one species in common with Europe.

Palm trees are more abundant in these islands than in any other part of the world, except tropical America, where the species exist in such great number and diversity. Three species of Areca, attaining a height of more than 40 or 50 ft., are cultivated in all the hot parts of India; and Caryota urens (the fruit of which is acrid, although the sap yields wine and sugar) is also a native. The attempt is vain to specify the multitudes of these graceful trees, which form so characteristic a feature in the vegetation of these tropical islands, where a rich moist soil with intense heat brings them to such perfection.

Jungles and dense woods entirely cover the smaller islands, and the plains of the larger; the coasts are lined with thickets of mangroves, a matted vegetation of forest trees, bamboos, and coarse grass, entwined with climbing and creeping plants, and overgrown by orchidaceous parasites in myriads: the gutta-percha is also a native of these alluvial tracts. The forest trees of the Indian Archipelago are extremely numerous; teak and many of the continental trees grow there, but the greater number are peculiarly their own. The naturalist Rumphius had a cabinet inlaid with 400 kinds of wood, the produce of Amboyna and the Molucca Islands.

Borneo and the adjacent islands are the region of the Dryobalanops camphora, in the stems of which beautiful amber coloured crystals of a remarkable and costly kind of camphor are found. There are thickets of the Pandanus or screw pine, a plant resembling a gigantic pineapple.

This is the region of spices, which are very limited in their distribution: the Myristica moschata (the nutmeg and mace plant) is confined to the Banda Islands, but it is said to have been discovered lately in New Guinea. The Amboyna and the Molucca groups are the focus of the Caryophyllus aromaticus, a myrtle, the flower buds of which are known as cloves. Various species of cinnamon and cassia, both of the laurel tribe, together with peppers, grow in this archipelago. All the pepper plants require great heat; the common black pepper is peculiar to the hottest parts of Asia, extending only a few degrees on each side of the equator. Some of the most excellent fruits are indigenous here only, as the durian, the ayer-aya, loquat, the choapa of the Moluccas, peculiar kinds of

orange, lemon, and citron, with others known only by name elsewhere, especially the mangosteen, which is almost peculiar. Those common to the continent of India are the jambose or rose apple, jack, pine apple, mango, and the banana.

Here the nettle tribe assume the most pernicious character, as the upas tree of Java, one of the most deadly vegetable poisons: and even the plants resembling our common nettle are so acrid that the sting of one in Java occasions not only pain but illness which lasts for days. A nettle in the Island of Timor, called by the natives the 'Devil's leaf,' is so poisonous that it produces long illness and even death. The chelik, a shrub growing in the dense forests, produces a poison even more deadly than the upas. Some of the fig genus, which is allied to the natural order of nettles, have acrid juices.

Sir Stamford Raffles describes the vegetation of Java as 'fearful.' In some of these forests the air is heavy, charged with dank and deadly vapours, rarely agitated by a breath of wind; the soil, of the deepest black vegetable mould, always moist and clammy, stimulated by the fervid heat of a tropical sun, produces trees the stems of which are of a spongy texture from their rapid growth, and loaded with parasites, particularly the orchidaceous tribes. Tree ferns form a large portion of the vegetation of Java and all these islands.

The Rafflesias, of which there are four species, are the most singular productions of this archipelago. The most extraordinary one was discovered in Sumatra by Dr. Arnold, and is therefore called Rafflesia Arnoldi. It is a parasitical plant, consisting of nothing but a flower, which vegetates in the prostrate stems of a gigantic vine. Its buds are the size of an ordinary cabbage, and the flower, which smells of carrion, is of a brick red colour, 3½ ft. in diameter. It weighs 15 pounds, and the cup in its centre could contain 12 pints of liquid.

According to Sir Stamford Raffles there are six distinct climates in Java, from the top of the mountains to the sea, each having an extensive indigenous vegetation. No other country can show an equal abundance and variety of native fruit and esculent vegetables. There are 100 varieties of rice; and of fragrant flowers, shrubs, and ornamental trees the number is infinite. Abundant as the Orchidaceæ are in Java, Ceylon, and the Burmese empire, these countries possess very few that are common to them all, so local is their distribution. Ferns are more plentiful in this archipelago than elsewhere; tree ferns are found chiefly between or near the tropics, in damp places.

§ 2. **Indian Flora.**—The plains of Hindustan are so completely sheltered from the Siberian blasts by the high mountain

ranges of Tartary and the Himalayas, and heated and watered by the monsoons, that the vegetation at the foot of that range already assumes a tropical character. In the jungles and lower ridges of the fertile valleys of the central and eastern Himalayas, and in the dark recesses of the Silhet and Malabar forests, arborescent ferns and orchidaceous plants are found in a profusion scarcely surpassed even in the islands of the Indian archipelago. The Khasya Mountains, S. of Assam, at the eastern extremity of Bengal, present one of the most varied and luxuriant vegetations on the globe.

The native fruits of India are many: the orange tribe is almost exclusively of Indian origin, though some of the species are now widely spread over the warmer parts of the four continents. The vine grows wild in the forests; plantain, banana, mango, date, areca, palmyra, and cocoa nut palms are all Indian. The Scitamineæ, or ginger tribe, are so numerous that they form a distinguishing and beautiful feature of Indian botany; they produce ginger, cardamoms, and turmeric. The flowers peculiar to India are brilliant in colour.

Trees of the fig tribe are among the most remarkable vegetable productions of India for gigantic size and peculiarity of form, and they are most valuable in a hot climate from the shade which their broad spreading tops afford. Some throw off shoots from their branches, which take root on reaching the ground and, after increasing in girth with wonderful rapidity, become themselves independent trunks; and this process is continued till a forest is formed round the parent tree. Mr. Reinwardt saw in the Island of Simao a large wood of the Ficus Benjamini which sprang from one stem. The Ficus Indicus, or banyan tree, is another instance of this wide spreading growth; there is a tree of it on the banks of the Narbada, in the province of Guzerat, with 350 main stems, occupying an area of 2000 ft. in circumference, independent of its branches, which extend much farther. The banana is a generally useful tree in India; its fruit is food, its leaves are applied to many domestic purposes, and flax fit for making muslin is obtained from its stem. Cotton is a hairy covering of the seeds of several species of the mallow tribe which grow spontaneously in tropical Asia, Africa, and America; it is, however, cultivated in many countries beyond these limits. That grown in China and the States of North America is an herbaceous annual from 18 inches to 2 ft. high: there are also cotton trees, native and cultivated, in India, China, Africa, and America. Herodotus mentions cotton garments 445 years B.C., and the Mexicans and Peruvians manufactured cotton cloth before the discovery of America.

Palms, the most stately and graceful of the vegetable productions of tropical regions, are abundant in India, in forests, in groups, and

in single trees. The stems of some are of gigantic size, and all are beautiful, varying in length from the slender Calamus, 130 ft. long, to the Phœnix acaulis, not more than 3 ft. high. Different species yield wine, oil, wax, flour, sugar, thread, and rope; weapons and utensils are made of their stems and leaves; they serve for the construction of houses; the cocoa nut palm gives food and drink.

Though palms in general are very limited in their distribution, a few species are very widely spread; for example, the cocoa nut palm is found in all the tropical regions of the globe, where it has been extensively cultivated from its usefulness. Their growth in Ceylon is extremely luxuriant. In parts of that island, on the Malabar and Coromandel coasts, and in some districts of Bengal, the Borassus flabelliformis supplies its place.

The Island of Ceylon, which may be regarded as the southernmost extremity of the Indian peninsula, is very mountainous, and in luxuriance of vegetable productions rivals the islands of the Indian archipelago, with the vegetation of which its own has the strongest affinity. The species of laurel, the bark of which is cinnamon, is indigenous, and is one of the principal sources of the revenue of Ceylon. The leaves of a species of palm, the talipot, are of enormous size, and are applied to many uses by the Cingalese: in ancient times strips of the leaf were written upon with a sharp style, and served as books. The sandal wood of Ceylon is of a different species from that of the South Sea Islands, and its perfume more esteemed. The mountains produce a great variety of beautiful woods used in cabinet work.

§ 3. **Arabian Vegetation.**—The third division of the tropical flora of Asia is the Arabian, which differs widely from the other two, and is chiefly marked by shrubs yielding balsams. Oceans of barren sand extend to the S., from Syria through the greater part of Arabia, varied only by occasional oases in those parts where a spring of water has reached the surface; there the prevalent vegetation consists of grasses, growing under the shade of date palms; acacias and stunted prickly bushes appear here and there in the sand. There is verdure on the mountains, and along some of the coasts, especially in the province of Yemen, which has a flora of its own. Eight species of figs, three species of amyris or balm of Gilead, opobalsamum also yielding balsam, and the kataf, from which myrrh is supposed to come, are found in Arabia. Frankincense is said to be the produce of the Boswellia serrata; and there are many species of Acacia, among others the Acacia arabica, which produces gum arabic. The chief characteristics of the Arabian flora, as distinguishing it from the Indian and Persian, are many species and genera of Abyssinian plants, among which

are found stapelias and other representatives of the Cape of Good Hope flora.

Arabia produces coffee which, however, is not indigenous, but is supposed to have come from the mountains of Abyssinia, and to have its name from the province of Kaffa, where it is said to form dense thickets. It was introduced into Arabia at the end of the fifteenth century, and grows luxuriantly in Arabia Felix, where the coffee is of the highest flavour. Most of that now used is the progeny of plants raised from seed brought from Mocha to the Botanic Garden at Amsterdam in 1690, by Van Hoorn, Governor of Batavia. A plant was sent to Louis XIV., in 1714, by the magistrates of Amsterdam—it was from this plant that the first coffee plants were introduced in 1717 into the West India Islands. A year afterwards the Dutch introduced coffee trees into Surinam, whence they spread rapidly over the warm parts of America and the West India Islands. Many thousands of people are now employed in its cultivation there, in Demerara, Java, Manilla, the Isle of Bourbon, and other places. Coffee was not known till many centuries after the introduction of sugar. The first coffee house was opened in London in 1652, and the first in France, at Marseilles, 1671.

CHAPTER XXVIII.

VEGETATION—*continued.*

§ 1. **African Flora.**—The N. coast of Africa, and the range of the Atlas generally, may be regarded as a zone of transition, where the plants of S. Europe and tropical Africa are mingled with those peculiar to the country. The majority of the plants of N. Africa are also found in the other countries on the shores of the Mediterranean. There are about six times as many *herbaceous plants* as there are *trees* and *shrubs*; and in the Atlas Mountains, as in other chains, the perennial plants are much more numerous than annuals. Evergreens predominate, and are the same as those on the other shores of the Mediterranean. The pomegranate, the locust tree, the oleander, and the palmetto abound; and the cistus tribe give a peculiar character to the flora. The sandarach, or Callitris articulata, peculiar to the N. side of the Atlas Mountains and to Cyrenaica, yields close grained hard timber, used for the ceiling of mosques. The Atlas produces seven or eight species of oak, and various pines, especially the Pinus maritima; and forests

of the Aleppo pine are found in Algeria. The sweet scented arborescent heath and Erica scoparia are native here, also in the Canary Islands and the Azores. The Pinus canariensis is peculiar, and also the Dracæna draco, which grows in perfection here. The stem of the great dracæna mentioned by Humboldt, at the Villa Orotava in Teneriffe, measures 46 ft. in circumference at the base of the tree, which is 75 ft. high. Though the group of the Canaries has plants in common with Spain, Portugal, Africa, and the Azores, yet there are many species, and even genera, which are found in them only; and the height of the mountains causes much variety in the vegetation.

On the continent S. of the Atlas a great change of soil and climate takes place; the drought on the borders of the desert is so excessive that no trees can resist it; rain hardly ever falls, and the scorching blasts from the S. speedily dry up any moisture that may exist; at the base of the mountains, however, the date palm forms large forests, which supply the inhabitants with food, and give shelter to crops which could not otherwise grow. The date palm, each tree of which yields from 150 to 160 pounds weight of fruit, grows naturally and is also cultivated through northern Africa.[1] It has been carried to the Canary Islands, Arabia, the Persian Gulf, and to Nice. Stunted plants are the only produce of the desert, yet large tracts are covered with the Pennisetum dichotomum, a harsh grass which, together with the Alhagi maurorum, is a great source of the food of camels.

The commoner plants of Egypt are acacias, cassias, tamarisks, Nymphæa lotus, and cærulea; also the zizyphus or jujube, and various mesembryanthemums. The date palm is found higher up the Nile than Thebes; it afterwards gives place to the dôm palm, or Crucifera Thebaica, peculiar to this district, and singular as being one of the few palms that have a branched stem.

The vegetation of western tropical Africa is best known along the coast, where some affinity with that of India may be observed. It presents a remarkable uniformity, not only in orders and genera, but even in species, from 16° N. lat. to the River Congo in 6° S. lat. The most prevalent orders are the grasses and Leguminosæ, the Cyperaceæ, Rubiaceæ, and Compositæ. The Adansonia, or baobab of Senegal, is one of the most extraordinary vegetable productions; the stem is sometimes 34 ft. in diameter, though the tree is rarely more than 50 or 60 ft. high; it covers the plains so entirely with

[1] The best dates are those grown near Tozzer in the Beled el Jerid, in lat. 34° N., a region which, like that of Jericho, once celebrated for its dates, has an extremely warm climate, supposed to be owing to its depression below the sea level.

its umbrella shaped top that a forest of these trees presents a compact surface which at some distance seems to be a green field. Cape Verd has its name from the numbers that conceal the barren soil under their spreading tops; some of them from their size were supposed to be the most ancient vegetable inhabitants of the earth; but their wood is so soft that this is very improbable. The Pandanus candelabrum, instead of growing crowded together in masses like the baobab, stands solitary on the equatorial plains, with its lofty forked branches ending in tufts of long stiff leaves. Numerous sedges give a character to this region and along with the grasses cover boundless plains, waving in the wind like corn fields, while other places are overgrown by forests of more gigantic grasses with branching stems.

Impenetrable thickets of mangrove cover the deltas of the rivers, and even grow so far into the water that their trunks are coated with shell fish; but the pestilential exhalations render it almost certain death to botanise amid this luxuriance of nature.

Various trees of the Sapota order are peculiar to Africa; the butter tree of the enterprising but unfortunate Mungo Park, the star apple, the cream fruit, the custard apple, and the water vine, are plentiful in Senegal and Sierra Leone. The safu and bread fruit of Polynesia are represented here by the musanga, a large tree of the nettle tribe, the fruit of which has the flavour of the hazel nut. A few palms have very local habitations, as the Elais guineensis, or palm oil plant, found only on the coast. That graceful tribe is less varied in species in equatorial Africa than in the other tropical continents.

The flora of South Africa is characterised by extensive miniature woods of heaths of which no less than 500 species are known. Some of these are from 12 to 15 ft. high and flower copiously throughout the greater part of the year. It includes also some stunted shrubs, succulent plants, and mimosas, along the margin of the river courses; after the rains vegetation is suddenly recalled to life, and in a short time the country is decked with a beautiful and peculiar flora. The Leucodendron argenteum, or silver tree, which forms groves at the back of Table Mountain, is confined to the peninsula of the Cape. The beautiful Disa grandiflora is found only in one particular spot on the top of Table Mountain.

The dry sand of the W. coast and the country northward, through many degrees of latitude, is the habitat of stapelias, succulent plants with leafless stems, and flowers like star fish, with the smell of carrion. A great portion of the E. frontier of the Cape colony and the adjacent districts is covered with extensive thickets of a strong succulent and thorny vegetation called by the

natives 'the bush:' similar thickets occur again far to the W., on the banks of the Guaritz. The most common plants of the bush are aloes of many species, all exceedingly fleshy and some beautiful: the great red flowering arborescent aloe, and some others, make a conspicuous figure in the E. part of the colony. Other characteristic plants of the eastern districts are the spek boem, or Portulaca afra, Schottia speciosa, and the great succulent euphorbias, which grow into real trees 40 ft. high, branching like a candelabrum, entirely leafless, prickly, and with a very acrid milky juice. The Euphorbia meloformis, 3 ft. in diameter, lies on the ground, to which it is attached by slender fibrous roots, and is confined to the mountains of Graaf Reynet. The succulent euphorbias, in the Old World, represent the Cactus tribe, which belong exclusively to the New. Cycadeæ, having the appearance of dwarf palms without any real similarity of structure, belong to the eastern districts, especially to the great tract of bush on the Caffir frontier.

Various species of Acacia are indigenous and much circumscribed in their location: the Acacia horrida, or white thorned acacia, is very common in the eastern districts and in Caffirland. The Acacia cafra is strictly eastern, growing along the margins of rivers, to which it is a great ornament. The Acacia detinens, or hook thorn, is almost peculiar to the Zand valley.

It appears from the instances mentioned that the vegetation of the E. districts of the colony differs from that of the W., yet many plants of orders and genera found only in this part of Africa are generally diffused:—Nearly all the 300 species of the fleshy succulent tribe of Mesembryanthemum, or Hottentot's fig; a great many beautiful species of the Oxalis, or wood sorrel tribe; every species of Gladiolus, with the exception of that in the corn fields of Italy and France; ixias innumerable, one with petals of apple green colour; geraniums, especially the genus Pelargonium, or stork's bill, almost peculiar to this locality; many varieties of Gnaphalium and Xeranthemum; the brilliant Strelitzia; 133 species of the houseleek tribe, all fleshy, attached to the soil by a strong wiry root, and nourished more or less from the atmosphere: Diosmas are widely scattered in great variety; shrubby Boragineæ with flowers of vivid colours, and terrestrial Orchideæ with large and showy blossoms. The leguminous plants and the Cruciferæ of the Cape are peculiar; indeed all the vegetation has a distinct character, and both genera and species are confined within narrower limits than is usual anywhere else, without any apparent cause to account for a dispersion so arbitrary.

Notwithstanding the peculiarity of character with which the botany of the Cape is so distinctly marked, it is connected with

that of very remote countries by particular plants. The affinity with Australia is great: in portions of the two countries in the same latitude there are several genera identical: Proteaceæ and Restiaceæ are abundant in both, and comparatively very rare elsewhere. Irideæ, Leguminosæ, Diosmeæ, and some others, are also most characteristic of both floras.

The vegetation of Madagascar, though similar in many respects to the floras of India and Africa, nevertheless has great peculiarity. The Hydrogeton fenestralis, or lattice leaf, a singular aquatic plant, with leaves like the skeletons of leaves, having no green substance between the veins; and the Tanghinia veneniflua, which produces a poison so deadly that its seeds are used to execute criminals, are natives of this country.

Some genera and species are common and peculiar to Madagascar, the Isle of Bourbon, and Mauritius. The three islands are rich in ferns. The Pandanus, or screw pine genus, abounds in Bourbon and the Mauritius, where it covers sandy plains, sending off strong aërial roots from the stem, which strike into the ground and enable the plant to resist the violent winds.

Eight or ten degrees N. of Madagascar lies the group of the Seychelles Islands, in one of which are groves of the peculiar palm, which bears the double cocoa nut, or *coco de mer*, the growth of this island only. Its gigantic leaves are employed in the construction of houses, and other parts of the plant are applied to various domestic purposes.

§ 2. **Flora of Australia**.—The flora of the Australian continent is of a strange and unexampled character. Several entire orders of plants are known only in Australia, and the genera and species of families that grow elsewhere here assume new and singular forms. Persistent-leaved trees, with hard narrow leaves of a sombre, melancholy hue, are prevalent, and there are whole shadowless forests of leafless trees; the foot stalks of the leaves, dilated and set edgewise on the stem, supply their place, and perform the functions of nutrition; their altered position gives them a singular appearance. Plants in other countries have glands on the under side of the leaves, but in Australia there are glands on both sides of these substitutes for leaves, and the changes of the seasons have no influence on the unvarying olive green of the Australian forests; even the grasses are to a great extent distinguished from those of other countries by a remarkable rigidity. These features are very much modified along the N. coast, which presents a less sombre character; but still the contrast of vegetation on the S. side of Torres Strait with the luxuriant jungle-clad shores of New Guinea, where deep and dark forests are rich in more than the usual tropical exuberance, is very great indeed. Mangrove swamps are

found at the mouths of the rivers which flow into the Gulf of Carpentaria.

The peculiarly Australian vegetation is found in the S. part of the continent distributed in distinct foci in the same latitude—a circumstance of which the Proteaceæ afford a remarkable instance. Nearly one half of the known species of this remarkable order grow in the parallel of Port Jackson, from which they decrease in number both to the S. and the N.; and the species of the S.W. quarter of the continent are, without an exception, different from those of the eastern.

The myrtle tribe form a conspicuous feature in Australian vegetation, particularly the genera Eucalyptus, Metrosideros, Leptospermum, and others, some bearing splendid blossoms—white, purple, yellow, and crimson: 100 species of the Eucalypti, most of them large trees, grow in Australia, many of them forming extensive forests. The leafless acacias, of which there are 93 species, are prominent features in the Australian landscape. The genus Casuarina, with its strange jointed drooping branches, holds a conspicuous place; it is chiefly confined to the principal parallel of this vegetation, and produces excellent timber; it grows also in the Malayan peninsula and the South Sea Islands. The Epacrideæ, with scarlet, rose, and white blossoms, supply the place of, and very much resemble, the true heaths, which do not exist here; the purple-flowering Tremandreæ; the yellow-flowering Dilleniaceæ; the Doryanthes excelsa, the most splendid of the lily tribe, 24 feet high, with a head of brilliant crimson blossoms, are all characteristic plants.

There is a change on the N.E coast of Australia. The Castanospermum australe is so plentiful that it furnishes the principal food of the natives; a caper tree of grotesque form, having the colossal dimensions of the Senegal baobab, and extraordinary trees of the fig genus, characterise this region. It sometimes occurs here, as in other tropical countries, that the seeds of these fig trees are deposited by birds on the branches of trees, that they vegetate and enclose the trunk entirely with their roots, sending up enormous lateral branches, which so completely envelop the tree, that at last its top alone is visible in the centre of the fig tree. The Pandanus genus flourishes both inland and within the influence of the sea air. There are several species of palms, equally local in their habitations as elsewhere, not one of which grows on the W. side of the continent. The Araucaria Cunninghamii produces the best timber of any tree in this part of Australia.

The S.W. districts of Australia exhibit another focus of vegetation, less rich in species than that of Port Jackson, but even more peculiar. The Kingia australis rises solitary on the sandy

plains, with tufts of long grassy leaves at the extremities of the bare trunks, which are blackened as if scathed by lightning, but in reality by the fires of the natives; Banksias are numerous; the Stylidium, whose blossoms are even more irritable than the leaves of the sensitive mimosa, and plants with dry, everlasting blossoms, characterise the flora of these districts. The greater part of the S. vegetation vanishes on the northern coasts of the continent, and what remains is mingled with the cabbage palm, various species of the nutmeg tribe, sandal wood, and other Malayan forms—a circumstance that may hereafter be of importance to our colonists. During Mr. Gregory's expedition in Western Australia he met with a very beautiful convolvulus, with numerous flowers from 2 to 3 inches in diameter, of a dark lilac deepening into a rich purple in the centre. It bears roots like a sweet potato, some of them more than a pound in weight and well flavoured, and forms an important article of food to the natives and if cultivated, it will be considered a valuable acquisition. A rock melon with fruit about the size of a pigeon's egg was met with also in great abundance.

Orchidiæ, chiefly terrestrial, are in great variety in the extra-tropical regions of Australia. Reeds of gigantic size form forests in the marshes, and the kangaroo-grass covers the plains.

Beautiful and varied as the flora of Australia is, it is by no means luxuriant. There is little appearance of verdure, the foliage is poor, the forests often shadeless, and the grass thin; always excepting valleys of the E. mountains, and even on some parts of the plains, where the vegetation is vigorous.

The flora of *Tasmania* is almost identical with that of S.E. Australia, especially the mountains of the Victoria colony. The plains glow with the warm golden flowers of the silver wattle, an acacia, the emblem of the island. Two tree ferns grow in this country; of which one rises 40 ft. to the base of the fronds, which spread into an elegant top, producing a shadow gloomy as nightfall; and there are also numerous species of Orchideæ.

The botany of *New Zealand* appears to be allied to that of Australia, South America, and the Pacific Islands. Noble trees form impenetrable forests, 60 of which yield timber, and many are of kinds to which we have nothing similar. Here there are no representatives of our oak, birch, or willow, but five species of beech and ten of Coniferæ have been discovered that are peculiar to the country. The Kauri pine, or Dammara australis, is found only in the North Island, where it grows in hilly situations, shooting up with a clean stem 60 or 90 ft., sometimes 10 ft. in diameter, and a spreading but thin top: it generally has a quantity of transparent yellow resin imbedded at its base. This fine tree

does not grow beyond 38° S. lat. The Metrosideros tomentosa, with rich crimson blossoms, is one of the greatest ornaments of the coasts; and other species of the genus abound in the forests. One palm only inhabits New Zealand, the Areca sapida. This country is probably the S. limit of the orchidaceous plants that grow on trees. Before New Zealand was colonised, the natives used the roots of the edible fern, Pteris esculenta, with which some parts of the country is densely covered. More than 120 species of fern are natives of these islands, some of which are arborescent and 40 ft. high; the country also produces the New Zealand flax, Phormium tenax, which grows abundantly both on the mountains and plains.

In Norfolk Island 152 species of plants are already known. The Cape gooseberry or Physalis edulis, the guava tree, and lemon trees, are introduced; also the bread fruit tree, which blossoms, but does not bear fruit. The Araucaria excelsa and some palms are indigenous, and there are three times as many ferns as of all the other plants together.

§ 3. **Flora of Polynesia.**—The multitude of islands of Polynesia constitute a botanical region apart from all others. The cocoa nut palm and the pandanus are common to all, but the latter thrives only when exposed to the sea air. This archipelago produces Tacca pinnatifida, which yields arrowroot; the Morus papyrifera, the bark of which is manufactured into paper; and one of the Arum tribe, from which an intoxicating liquor is made. Fifty varieties of the bread fruit tree are indigenous, which produce three or four crops annually. It is most abundant in the Friendly, Society, and Caroline groups, whence it has been taken to America, where it thrives in very low latitudes.

The Sandwich group is peculiar for the number of Lobelias; while the coral islands, with a flora which is entirely borrowed, rarely have two species belonging to the same genus; the fragrant Suriana and sweet-scented Tournefortia are among their scanty vegetation.

The 2 species of banana trees which are natives of southern Asia, were introduced at an unknown and probably early period into the Polynesian islands, and all tropical countries in the eastern and western hemispheres. Syria is their N. limit, where the Musa paradisiaca grows to 34° N. lat. The sweet fruit of these trees produces, on the same extent of ground, 44 times as much nutriment as the potato, and 133 times more than wheat.

St. Helena, Mauritius, the Sandwich group, New Zealand, Juan Fernandez, and above all the Galapagos Islands, are more peculiar in their floras than any other tracts of their size. The Galapagos archipelago consists of 10 principal islands lying immediately under

the equator, 600 m. from the coast of America. They are entirely volcanic, and contain 2000 extinct craters. The vegetation is so peculiar that, of 185 species of flowering plants which have been collected, 100 are found nowhere else; of 21 species of Compositæ all but one are indigenous and belong to 12 genera, 10 of which are exclusively confined to these islands.

This flora has no analogy with that of Polynesia, but it has an undoubted W. American character. The plants peculiar to the Galapagos Islands are for the most part allied to those on the cooler part of the continent or on high lands, while the others are the same with those that abound in the hot, damp, intertropical regions of the continent. The greatest number of peculiar plants grow on the tops of the islands where the sea vapour is condensed, and many of them are confined to some one islet of the group. Though this flora is singular it is poor compared with that of the Sandwich group, or the Cape De Verd Islands.

CHAPTER XXIX.

VEGETATION—*continued.*

§ 1. **Flora of North America.**—From similarity of physical circumstances the Arctic flora of America bears a strong resemblance to that of the N. regions of Europe and Asia. This botanical district comprises Greenland, and extends considerably to the S. of the Arctic Circle, especially at the E. and W. ends of the continent, where it reaches 60° N. lat., and even more; it is continued along the tops of the Rocky Mountains almost to Mexico, and it re-appears on the White Mountains and a few other parts of the Alleghanies.

Greenland has a much more Arctic flora than Iceland; the valleys present numerous mosses and marsh plants, the gloomy rocks are sprinkled with sombre lichens, and the grasses on the pasture grounds that line the fiords are nearly four times less varied than those of Iceland. In some sheltered spots the service tree bears fruit, and birches grow to the height of a few feet; but ligneous plants in general trail on the ground.

Although the Arctic flora of America has much the same character as that of Europe and Asia, most of the species being common to all, there is yet a difference in the vegetation at the two extremities of the continents. The sameness of character changes with the barren treeless lands at the verge of the Arctic region, where the distribution of plants varies both with the lati-

tude and the longitude. Taking a broad view of the botanical districts of North America, there are two woody regions, one on the E., the other on the W. side of the continent, separated by a region of prairies where grasses and herbaceous plants predominate. The vegetation of these three parts, so dissimilar, varies with the latitude, but not after the same law as in Europe, for the winter is much colder and the summer warmer on the E. coasts of America than on the W. shores of Europe, owing in a great measure to the prevalence of W. winds which bring cold and damp to our shores.

Boundless forests of black and white spruce, with an undergrowth of reindeer moss, cover the country S. of the Arctic region which still further S. are afterwards mixed with other trees. There are vast forests in Canada of pines, oak, ash, hickory, red beech, birch, the lofty Canadian poplar, sometimes 100 ft. high and 36 ft. in circumference, and sugar maple; the prevailing shrubs are Kalmias, Azaleas, and Asters, the former vernal, the latter autumnal; solidagos and asters are the most characteristic plants of this region.

The splendour of the North American flora is displayed in the E. States; the American sycamore, chestnut, black walnut, hickory, white cedar, wild cherry, red birch, locust tree, tulip tree, or Liriodendron, the glory of American forests, liquidambar, oak, ash, pine trees of many species, grow luxuriantly, with an undergrowth of Rhododendrons, Azaleas, Andromedas, Gerardias, Calycanthus, Hydrangea, and many more of woody texture, with an infinite variety of herbaceous and climbing plants.

The vegetation is different on the two sides of the Alleghany Mountains; the Locust tree, Canadian poplar, Hibiscus, and Hydrangea, are most common on the W. side; the American chestnut and Kalmias are so numerous on the Atlantic side as to give a distinctive character to the flora: here, too, aquatic plants are more frequent: among these is the Sarracenia or side-saddle flower, singular in form, with leaves like pitchers covered with a lid, half full of water.

The autumnal tints of the forests in the States are beautiful and of endless variety; the dark leaves of the evergreen pine, the red foliage of the maple, the yellow beech, the scarlet oak, and purple Nyassa, with all their intermediate tints, ever changing with the light and distance, produce an effect at sunset that would astonish the native of a country accustomed to a more sober coloured flora under a more cloudy sky.

In Virginia, Kentucky, and the S. States the vegetation assumes a different aspect, though many plants of more northern districts are mixed with it. Trees and shrubs here are remarkable for broad shining leaves and splendid blossoms, as the Gleditschia,

Catalpa, Hibiscus, and the family of Magnolias. They are the distinguishing feature of the flora from Virginia to the Gulf of Mexico, and from the Atlantic to the Rocky Mountains: the Magnolia grandiflora and the tulip tree are the most splendid specimens of this tribe of plants; the latter is often 120 ft. high. The long leaved pitch pine, one of the most picturesque of trees, covers an arid soil on the coast of the Atlantic, of 60,000 sq. m. The swamps so common in the S. States are clothed with the gigantic deciduous cypress, the aquatic oak, and swamp hickory, whilst the rare and magnificent Nelumbium luteum and other aquatics grow there; and among the innumerable herbaceous plants the singular Dionæa muscipula, or American fly trap: the trap is formed by two opposite lobes of the leaf, edged with spines, and so irritable that they instantly close upon the insect that lights on them. This Magnolia region corresponds in latitude with the S. shores of the Mediterranean, but the climate is hotter and more humid, in consequence of which there is a considerable number of Mexican plants. A few dwarf palms appear among the Magnolias, and the forests in Florida and Alabama are covered with Tillandsia usneoides, an air plant which hangs from the boughs.

Many species of *grass* cover the extensive prairies of the valley of the Mississippi. The forms of the Tartarian steppes appear to the N. in the Centaureas, Artemisias, Astragali; but many more are peculiar. The Helianthus and Coreopsis, mixed with some European genera, mark the middle regions; and in the south, towards the Rocky Mountains, Clarkia and Bartonia are mixed with the Mexican genera of Cactus and Yucca. The W. forest is less extensive and less varied than the E., but the trees are larger. This flora in high elevations is but little known: the Thuja gigantea on the Rocky Mountains and the coast of the Pacific is 200 ft. high. Claytonias and currants, with plants of N. Asia, are found here.

The forests of British Columbia and Vancouver's Island abound in Coniferæ, the red and yellow cedar and pines. The birch, maple, and hazel are found in British Columbia, and oaks in the S. of Vancouver's Island. The wild rose, sweet briar, and berry-bearing bushes are numerous, and cranberries are so abundant that they are exported to San Francisco. Hemp and flax grow wild, and from the fibres of the Urtica Cannabina the Indians manufacture twine, rope, and nets. The coast mountains of California have pine valleys in which the burr oak, with elm-like branches, is a distinguishing tree. Oaks, pines, laurels, cypresses, the madrona, the mazanita, and the gigantic redwood are found on the tops of the hills and in the close cañons. The timber of the redwood is used for building. The forests of the Sierra Nevada

have a wide variety of oaks, pines, firs, cypresses, and cedars. The sugar pines are distinguished by huge cones hanging all over their tops. These trees are sometimes 300 ft. high, and 8 or 10 ft. in diameter; they furnish fine timber.

The Pinus Lambertiana is an instance of the stupendous trees of the W. flora; many species of pine are indigenous in California, among which is the mammoth tree, or Wellingtonia (*Sesquoia gigantea*), which attains from 200 to 300 and even 325 ft. in height, and 100 ft. in girth, and some plants of which are supposed to be 2000 years old. The mammoth trees are scattered among the other trees of the forests at some eight different places along the side of the Sierra Nevada, at elevations of from 4000 to 7000 ft., and within a distance of 150 m. S. of the centre of the state of California. None have been found out of this line. The Calaveras grove of Big Trees is the most northerly; the Mariposa grove, containing about 600 trees, 125 of which are over 40 ft. in circumference, and several from 90 to 100 ft., has been set apart to be preserved by the State. 'The bark of these trees is of a light cinnamon colour, fluted up and down the long, straight, slowly tapering trunk, like Corinthian columns in architecture; the top, resting like a cap upon a high bare mast, is a perfect cone; and the evergreen leaves wear a bright light shade, by which the tree can be distinguished from afar in the forest. The wood is a deep rich red in colour; the bark is sometimes as much as 20 inches thick.'[1] This is the native soil of the currant bushes with red and yellow blossoms, of many varieties of lupins, pæonies, eschscholtzias, and other herbaceous plants so ornamental in our gardens.

Amongst the native fruits of North America the hickories are the most celebrated, and there are many of these; to which may be added, in the S. States, the Chicasaw plum, the papaw, the banana, the red mulberry, and the plumlike fruit of the persimon. There are several species of wild grapes, of which one produces an excellent wine, and is largely cultivated. North America has contributed much to the ornament of our pleasure grounds and gardens, and has also borrowed largely from other parts of the globe. Tobacco, Indian corn, and many other plants of the utmost commercial value, are strangers to the soil, having been introduced by the earliest inhabitants from Mexico and South America.

§ 2. **Flora of Mexico and the West Indies.**—Mexico itself unites the vegetation of North and South America, though it resembles that of the latter most nearly. Whole provinces on the table-land and mountains produce alpine plants, oaks, chestnuts, and pines spontaneously.

[1] Bowle's 'Our New West.'

The low lands of Mexico and Central America have a very rich flora consisting of many plants peculiar to them. The Hymenea Courbaril, from which the copal of Mexico is obtained, Logwood, Mahogany, and many other large trees valuable for their timber, grow in the forests; Sugar Cane, Tobacco, Indigo, American aloe, Yam, Capsicum, and Yucca are indigenous in Mexico and Central America. It abounds in species of the Melastomas and Passifloræ. The Pine Apple is entirely American; it has been carried to, and naturalised in, all the tropical countries of the Old World. This country also produces the Cherimoya, said to be the most excellent of fruits. Much of the Vanilla which is used in Europe comes from the states of Vera Cruz and Oaxaca, on the E. slopes of the Cordillera of Anahuac in Mexico. Hot arid tracts are covered with the Cactus tribe. They are social plants, inhabiting sandy plains in thickets, and of many species: their forms are various and their blossoms beautiful. A few occur at a considerable distance from the tropics, to the N. and the S. An opuntia grows in the Rocky Mountains; and Sir George Back found a small island in the Lake of the Woods covered with it. In Mexico the cochineal insect was collected from the Cactus coccinellifer long before the Spanish conquest. There are large fields of American aloe, from which a fermented liquor called *pulque*, and also an ardent spirit, is made. The ancient Mexicans made their hemp from this plant, and also their paper. The forests of Panama contain at least 97 different kinds of trees which grow luxuriantly in a climate where the torrents of rain are so favourable to vegetation, and so unfavourable to human life, that the tainted air is deadly. Maize or Indian corn is believed to have come originally from Mexico and South America. It is an annual, requiring only summer heat; its limit is 50° N. in the American continent, and 47° N. in Europe; it ripens at an elevation of 7600 ft. in low latitudes, and in the lower Pyrenees at the height of 3289 ft.[1]

The flora of West India is characterised by the prevalence of ferns and orchids, and the vegetation is allied to that of the N. part of South America and Mexico. The Myrtus pimento, producing allspice, the Custard apple, Guava, Alligator pear, and Tobacco are indigenous.

§ 3. **Flora of Tropical America.**—The flora of tropical America is so varied that it is not possible to convey an idea of the peculiarities of this vegetation, or of the extent and richness of its woodlands. The upper Orinoco flows for some hundreds of miles chiefly through forests; and the forests of the Amazons are

[1] In the Island of Titicaca, in Peru-Bolivia, Mr. Pentland has seen a variety of maize ripen as high as 12,493 ft.

six times the size of France. In these the trees are colossal, and the vegetation so matted together by underwood, creeping and parasitical plants, that the sun's rays can scarcely penetrate the dense foliage.

These extensive forests are by no means uniform: they differ to some extent on each side of the equator, though climate and other circumstances are similar. So partial is this splendid vegetation that each of the great rivers has many species peculiar to its banks; particular families of plants predominate where they occur, and change the appearance of the forest. Thus, from the prevalence of the orders Lauraceæ, Sapotaceæ, and others, which have leathery, shining, and entire leaves, the forests through which the Rio Negro and Cassiquiare flow, differ in aspect from those on the other affluents of the Amazon. Even the grassy llanos so uniform in appearance have their centres of vegetation, and only agree with the pampas of Buenos Ayres in being covered with grass and herbs.

On the Andes, almost at the limit of vegetation, the ground is covered with purple, azure, and scarlet Gentians, Drabas, Alchemillas, and many other brilliantly coloured alpine plants. This zone is followed by thickets of coriaceous leaved plants, in perpetual bloom and verdure; and then come the forest trees. Arborescent ferns ascend to 7000 ft.; the Coffee trees and Palms to 5000; and neither Indigo nor Cacao can be cultivated higher than 2000. The tree yielding cacao, of which chocolate is made, grows wild in Guiana, Mexico, in the inland forests of Peru and Bolivia, and on the coast of Venezuela; it is now cultivated in Central and South America, and in the Philippine Islands, where it was introduced by the Spaniards. The seeds of its fruit, which is like a cucumber, are the cacao or chocolate bean.

Many parts of the coast of Venezuela and Guiana are rendered pestilential by swamps covered with mangroves. The well known poison Ourari or Wourali is prepared by the Indians of Guiana from the fruit and bark of the Strychnos toxicaria, probably the most deadly plant which nature has produced. It is a creeping plant which yields this deadly juice, the powerful effect of which was first proved by Mr. Waterton's experiments.

The Cinchona, or true bark tree, consisting of several species, is a native of the eastern declivities of the Andes;[1] but, under the direction of the Dutch government, it has been transplanted to

[1] Dr. Weddell, a distinguished English botanist, employed by the French Government, who has explored the districts along the eastern declivities of the Peru-Bolivian Andes which furnish the Peruvian bark of commerce, has discovered several new species of Cinchona, the total number of which, according to his very interesting monograph, now amounts to

Java, where it is now cultivated, and still more recently by Mr. C. R. Markham, and others acting under the orders of the Council of India, into the hilly countries of southern India, also into Curg, Mysore, the Bombay Presidency, and into the neighbourhood of Darjiling, and into Jamaica.[1] Some of its medicinal qualities are found in other plants of different genera in Guiana, as the Cusparia, which produces the Angostura bark. The Sapindus saponarius, or soap tree, is used by the natives for washing. Capsicum, Vanilla, and Cassava or mandioca, are natives of the country. There are two kinds of mandioca, a shrub the fleshy roots of which yield a farina eaten by the natives of Spanish America and Brazil: the root of one (called *Yuca* in Peru) is harmless, but the other (*Manihot utilissima*) contains a poisonous milky juice, the effects of which are removed by the washing or pressure of the pulp. From the starch of the latter, tapioca is prepared. It grows to about 30° on each side of the equator, and to 3200 ft. above the sea level. An acre of mandioca is said to yield as much nourishment as 6 acres of wheat.

The Arrowroot plant (*Maranta Arundinacea*) is a native of the American continent, from which it has spread to most tropical countries. The substance (an edible starch, obtained from the root stock of the *Maranta* species) owes its English name to the belief that the juice of the Marantas is an antidote to the poison of the arrows of the Indians. The Cow tree, almost confined to the mountains of the coast of Venezuela, yields an abundance of nutritious milky juice like that of a cow. The Theobromæ, or cacao trees, fruits of the most excellent flavour, and plants yielding balsam, resin, and gum, are numerous in the tropical regions. There the Laurel tribe assume the character of majestic trees; some are so rich in oil, that it gushes from a wound in the bark. One of these laurels produces the essential oil which dissolves caoutchouc, or Indian rubber, used in rendering cloth waterproof.

Palms are the most numerous and the most beautiful of all the trees in these countries. There are several hundred species of them; and they are so local that a change takes place every 50 m. They are the greatest ornament of the upper Orinoco.

The llanos of Venezuela and Guiana are covered with high grass, mixed with lilies and other bulbous flowers, sensitive mimosas, and palms constantly varying in species.

21.—(Weddell, 'Histoire Naturelle des Quinquinas,' 1 vol. folio, avec 34 planches, Paris, 1849.) And Mr. Howard has added some more in his additions to the 'Quinologia' of Pavon.

[1] See Mr. Markham's 'Travels in Peru and India while superintending the Collection of Cinchona Plants and Seeds in South America, and their Introduction into India.'

No language can describe the glory of the forests of the Amazon and Brazil, the endless variety of form, the contrasts of colour and size: there even the largest trees bear brilliant blossoms; scarlet, purple, blue, rose colour, and golden yellow, are blended with every possible shade of green. Majestic trees, as the Bombax ceiba (or silk-cotton tree), the dark leaved Mora with its white blossoms, the Fig, Cashew, and Mimosa tribes, which are here of unwonted dimensions, and a thousand other giants of the forest, are contrasted with the graceful palm, the delicate acacia, reeds of 100 ft. high, grasses of 40, and tree ferns. Passifloræ and slender creepers twine round the lower plants, while others as thick as cables climb the lofty trees, drop again to the ground, rise anew, and stretch from bough to bough, wreathed with their own leaves and flowers, yet intermixed with the vividly coloured blossoms of the Orchidaceæ. It may here be remarked that one of the most noticeable features in tropical forests is their prevailing greenness, for the leaves do not change their colours as in extratropical countries. Magnificent blossoms do occur, but there is no blaze of gorgeous colouring. An impenetrable and everlasting vegetation covers the ground; decay and death are concealed by the exuberance of life; the trees are loaded with parasites while alive—they become masses of living plants when they die. Here, too, occurs the Siphonia elastica, that invaluable tree the juice of which, known as India rubber, has become one of the most important substances in commerce.

The forests on the banks of the Paraguay and Vermejo are almost as rich as those of the tropics. Noble trees furnish timber and fruit; the Algaroba, a kind of acacia, produces clusters of a bean of which the Indians make bread, and also a strong fermented liquor; forests of the Copernicia cerifera, or wax-palm, grow there; and so does the Yerba-maté, the leaves and twigs of which are universally used as tea in South America, and were in use before the Spanish conquest. It is a species of holly, with leaves three inches long.

The sandy deserts towards the mountains are the land of the cactus in all its varieties. Some larger species of cactus give a light and durable timber for building; and the cochineal insect, which feeds on one of them, is a valuable article of commerce.

§ 4. **Flora of Extratropical South America.**—Grass, clover, European and African thistles, which have been introduced, are the almost unvarying features of the pampas; and thorny stunted bushes, characteristic of all deserts, are the only vegetation of the Patagonian shingle. But in the mountain valleys in the far S. may be seen the winter's bark, beech trees, stunted berberries, and numerous trees and shrubs.

Large forests of Araucaria imbricata grow on the sides of the

Andes of Chili and Patagonia. This tall and handsome pine, with cones the size of a child's head, supplies the natives with a great part of their food. It is said that the fruit of one large tree will maintain 18 persons for a year.

Nothing grows under these great forests; and when accidentally burnt down in the mountainous parts of Patagonia, they never rise again, but the ground they grew on is soon covered with an impenetrable brushwood of other plants. In Chili the violently stinging Loasa appears first in these burnt places, bushes grow afterwards, and then comes a tree-grass, 18ft. high, of which the Indians make their huts.

The S. coasts of Chili are very barren, and all plants existing there, even the herbaceous, have a tendency to assume a hard, knotty texture. The stem of the wild potato, which is indigenous in Chili, becomes woody as it grows old. It is a native of the sea strand, and is never found naturally more than 400 ft. above it. In its wild state the tuber is small and bitter; it is one of many instances of the influence of cultivation in rendering unpromising plants useful to man. It was cultivated in America at the time of its discovery, and is so now, at the height of from 9800 to 13,000 ft. above the sea on the Andes, and as high as 4800 ft. on the Swiss Alps; it rarely succeeds on the plains in hot countries, nor farther N. than Iceland. It had been introduced into Europe by the Spaniards before the time of Sir Walter Raleigh; he brought it to England from Virginia in 1586.

Coca, the Erythroxylon coca of botanists, is a native of the tropical valleys on the eastern declivity of the Andes of Peru and Bolivia, where it is extensively cultivated for its leaf, of which the tree furnishes three or four crops annually; the coca leaf is chewed by the aborigines mixed with an alkaline substance: it acts as a stimulant like opium; it is an article of great trade, being used by the aboriginal population of the Andes and the Upper Amazons.

Between 33° and 45° S. lat. Chili is covered with extensive forests—stately trees of many kinds, having smooth and bright-coloured trunks bound together by parasitical plants; large and elegant ferns are numerous, and arborescent grasses entwine the trees to the height of 20 or 30 ft.; palm trees grow to 37° S., which appears to be their southern limit.

Although the flora, at an elevation of 9000 ft. on the Chilian Andes, is almost identical with that about the Strait of Magellan, yet the climate is so mild in some valleys, that of Antuco for example, that the vegetation is semi-tropical. In it broad leaved and bright coloured plants, and the most fragrant and brilliant Orchidaceæ, are mixed with the usual alpine genera.

The humidity or dryness of the prevailing winds makes an

immense difference in the character of the countries on each side of the Andes. Within the S. tropic the trade winds come loaded with vapour from the Atlantic, which is partly precipitated by the mountains of Brazil, and supplies the noble forests of that country with never ceasing moisture, while the remainder is condensed by the Andes; so that on their E. side there is an exuberant vegetation, while on the W. declivities and in the space which separates them from the Pacific the land is almost barren, and on the plains and in the valleys of Peru, where rain very seldom falls, completely so, except where artificial irrigation is employed. Even on the E. side of these mountains the richness of the vegetation gradually disappears with the increasing height, till at an elevation of about 15,000 ft. arborescent plants vanish, and alpine races, of the most vivid beauty, succeed; these in their turn give place to grasses at the height of 16,000 ft. Above that limit are dreary plains where even the thinly scattered mosses are sickly; and at a height exceeding 20,000 ft. the snow-lichen forms the last show of vegetable life on the rocky peaks projecting from the snow.

§ 5. **Antarctic Flora.**—Kerguelen Land and Tierra del Fuego are the northern boundary of the antarctic lands, which are scattered round the S. pole at immense distances from one another. On these the vegetation decreases as the latitude increases, till all but utter desolation prevails, long before reaching the Polar circle; beyond this not a lichen covers the dreary storm beaten rocks; and, with the exception of a few microscopic marine plants, not a seaweed lives in the gelid waves. In the arctic regions, on the contrary, no land has yet been discovered that is entirely destitute of vegetable life. This remarkable difference does not so much depend on a greater degree of cold in winter as on the want of warmth in summer. In the high northern latitudes the power of the summer sun is so great as to melt the pitch between the planks of the vessels; while in corresponding southern latitudes the thermometer does not rise above 14° Fahr. at noon at a season corresponding to our August. The perpetual snow reaches to a much lower latitude in the S. lands than it does in the N. Sandwich-land, in a latitude corresponding to that of the N. of Scotland, is in parts perpetually covered with snow. A single species of grass, the Aira antarctica, is the only flowering plant in the South Shetland group, which is no less ice-bound; and Cockburn Island, which forms a part of it, in 60° S. lat., contains the last vestiges of vegetation; while the Shetlands in our hemisphere, in an equally high latitude, are inhabited and cultivated: nay, South Georgia, in a latitude similar to that of Yorkshire, is always clad in frozen snow, and only produces some mosses, lichens, and one or two herbaceous plants; while Iceland, 10 degrees nearer the pole, has 870 species, more than half of which are flower-bearing.

The forest-covered islands of Tierra del Fuego are only 360 m. from the desolate South Shetland group: such is the difference that a few degrees of latitude can produce in these antarctic regions, when combined with an equable climate and excessive humidity.

The prevalence of evergreen plants is the most characteristic feature in the Fuegian flora. Densely tangled forests of beech trees grow from the shore to a considerable height on the mountains. Of these the Fagus betuloides, which never loses its leaves, prevails almost to the exclusion of the evergreen winter's bark and the deciduous beech, which is very beautiful. There are dwarf species of Pernettya, the Myrtus nummularia, which is used instead of tea, besides berberry, currant, and fuchsia, which is a native of Fuegia; peculiar species of Ranunculus, Calceolarias, Caryophyllaceæ, Cruciform plants, and Violets. Wild celery and scurvy-grass are abundant; and a bright yellow fungus, which grows on the beech trees, forms a great part of the food of the natives. There is a greater number of plants in Tierra del Fuego either identical with those in Great Britain, or representatives of them, than exists in any other country in the southern hemisphere. The Sea pink, or thrift, the common Crowberry-wort, Primula farinosa, and at least 30 other flowering plants, with almost all the lichens, 48 mosses, and many other plants of the cryptogamous kind, are identical, while a number of genera common to both countries, though unknown in the intermediate latitudes, reappear here. An alpine flora, many of the species of European genera, grows on the mountains, succeeded higher up by mosses and lichens.

Although the Falkland Islands are in a lower latitude than Tierra del Fuego, not a tree is to be seen. The Veronica elliptica, resembling a myrtle, which is extremely rare and confined to West Falkland, is the only large shrub. A white-flowering plant like the aster, about four feet high, is common: while a Bramble, a Crowberry, and a Myrtle, bearing no resemblance, however, to the European species, trail on the ground and afford edible fruit. The Bog balsam, or Bolax glebaria, and the Dactylis cæspitosa, or tussac grass, form the only conspicuous features in the botany of these islands, and grasses cover them, almost to the exclusion of other plants. The bolax grows in tufted hemispherical masses of a yellow green colour and very firm substance, often four feet high, and as many in diameter, whence a strong-smelling resinous substance exudes, the odour of which is perceptible at a distance. This plant has umbelliferous flowers, but forms an alpine and antarctic genus quite peculiar.

The Tussac grass is the most useful and the most singular plant in this flora. It covers all the small islands of the group, and thrives best on the shores exposed to the spray of the sea. Each

tussac is an isolated plant, occupying about two square yards of ground. It forms a hillock of matted roots, rising straight and solitary out of the soil, often 6 ft. high and 4 or 5 in diameter, from the top of which it throws out a thick grassy foliage of blades, 6 ft. long, drooping on all sides, and forming, with the leaves of the adjacent plants, an arch over the ground beneath, which yields shelter to sea-lions, penguins, and petrels. Cattle are exceedingly fond of this grass, which yields annually a much greater supply of excellent fodder than the same extent of ground would do either of common grass or clover. Both the tussac-grass[1] and the bolax are found, though sparingly, in Tierra del Fuego; indeed, the vegetation of the Falkland Islands consists chiefly of the mountain plants of that country and of those that grow on the arid plains of Patagonia; but it is kept close to the ground by the fierceness of the terrific gales that sweep over these antarctic islands. Peculiar species of European genera are found here, as a wood sorrel, and a yellow violet; while the Cardamine hirsuta and the Primula farinosa appear to be identical with those at home. In all, there are scarcely 120 flowering plants, including grasses. Ferns and mosses are few; but lichens are in great variety and abundance, among which many are identical with those in Britain.

The flora of Campbell's Island and the Auckland group is so intimately allied to that of New Zealand that it may be regarded as the continuation of the latter, under an antarctic character, though destitute of the beech and pine trees. There is a considerable number of Fuegian plants in these islands, though they are 4000 m. distant; and whenever their flora differs in the smaller plants from that of New Zealand, it approximates to that of Antarctic America; but the trees and shrubs are entirely dissimilar. The relation between this vegetation and that of the northern regions is but slight. The Auckland group and Campbell's Island are in a latitude corresponding to that of England, yet only 3 indigenous plants of our island have been found in them, namely, the Cardamine hirsuta, Montia, and Callitriche. This is the utmost S. limit of tree ferns.

The Auckland islands lie in the boisterous ocean S. of New Zealand. They are covered with dense and all but impenetrable thickets of stunted trees, or rather shrubs, about 20 or 30 ft. high, gnarled by gales from a stormy sea. There is nothing analogous to

---

[1] The cultivation of this useful plant was introduced into some of the western islands of Scotland, especially Lewis, by the proprietor, Sir James Matheson. It thrives well in peaty soils within the influence of the sea-spray.

these shrubs in the N. hemisphere; but the Veronica elliptica, a native of Tierra del Fuego and New Zealand, is one of them. Fifteen species of ferns find shelter under these trees, and their fallen trunks are covered with mosses and lichens. Eighty flowering plants were found during the stay of the Antarctic expedition, of which 56 were then new to science; many are peculiar to this group and to Campbell's Island, but the greater proportion are natives of the mountains of New Zealand. Some of the most beautiful flowers grow on the mountains, others are mixed with the ferns in the forests. A beautiful plant was discovered, like a purple aster; a Veronica, with large spikes of ultramarine colour: a white one, with a perfume like jessamine; a sweet-smelling alpine Hierochloe; and in some of the valleys the fragrant and bright yellow blossoms of a species of asphodel were so abundant as to be visible to ships sailing along the coast. There are also antarctic species of European genera, as beautiful red and white gentians, geraniums, &c. The landscape, though picturesque, has a sombre aspect, from the prevalence of brown dark evergreen-leaved plants.

Campbell's Island lies 120 m. S. of the Auckland group, and is much smaller, but from the more varied form of its surface it is supposed to produce as many species of plants. During the two days the discovery ships under the command of Sir James Ross remained there, between 200 and 300 were collected: of these 66 were flowering plants, and 14 were peculiar to the country. Many of the Auckland Island plants were found here, yet a great change had taken place; 34 species had disappeared, and were replaced by 20 new, all peculiar to Campbell's Island, and some were found that hitherto had been supposed to belong to Antarctic America only.

Perhaps no spot in either hemisphere, at the same distance from the Pole, is more barren than Kerguelen Land, lying in a remote part of the South Polar ocean. Only 18 species of flowering plants were found there, which is less than the number in Melville Island, in the Arctic Seas, and 3 times less than the number in Spitzbergen. The whole known vegetation of this island only amounts to 150 plants, including seaweeds. The Pringlea, a kind of cabbage, acceptable to those who have been long at sea, is peculiar to the island, and grass, together with a plant similar to the bolax of the Falkland Islands, covers large tracts. About 20 mosses, lichens, &c., only are found in this island, but many of the others are also native in the European Alps and north polar regions. It is a very remarkable circumstance in the distribution of plants, that there should be so much analogy between the floras of places so far apart

as Kerguelen Land, the groups S. of New Zealand, the Falkland Islands, South Georgia, and Tierra del Fuego.

§ 6. **Origin and Distribution of Cerealia.**—The plants which the earth produces spontaneously are confined within certain districts; nevertheless Providence has endowed those most essential to man with so much power of adapting themselves to changes of climate and locality that the limits of their production can be extended by culture beyond what have been assigned to them by nature. The grasses yielding the grains are especially favoured in this respect, though their extension depends upon the knowledge and industry of man; so that with regard to useful plants there is an artificial as well as a natural boundary. The cultivation of plants in gardens and hot houses is entirely artificial, and depends on luxury and fashion.

Tartary and Persia are presumed to have been the original countries of wheat and rye, and the Caucasus that of oats; but these grains have been so long in use that it is impossible to trace their origin with certainty. In high northern latitudes wheat is protected from the inclemency of winter by sowing it in spring, or if sown in autumn a coating of snow defends it: the polar limit is the isothermal line of 57° 2′, and wheat will not form seed within the tropics, except at a considerable height above the sea. In America the northern limit is unknown, the country being uninhabited; but at Cumberland House, in the very middle of the continent, one of the stations of the Hudson Bay Company, in 54° N. lat., wheat, barley, and maize are grown. Wheat thrives luxuriantly in Chili and Peru, and at elevations of 8500 and 10,000 ft. above the sea. It even produces grain on the banks of the Lake Titicaca, in the Peru-Bolivian Andes, at the height of 12,493 ft., in sheltered situations, and good crops of barley are raised in that elevated region.

Barley bears cold better than any of the grains, yet neither it nor any other will grow in Iceland. It is successfully cultivated in the Faröe Islands; near North Cape, the extreme point of Norway; near Archangel on the White Sea; and in Central Siberia to between 58° and 59° N. lat.

Rye is only cultivated where the soil is very poor, and agriculture little understood; yet a third of the population of Europe lives on rye bread, chiefly inhabitants of the middle and especially of the N. parts: its limit is about 67° N. lat.

Oats are scarcely known in middle and S. Europe; in the N. they are extensively cultivated to 65° N. lat.

Rice is the food of a greater number of human beings than any other grain: it has been cultivated from such high antiquity that all traces of its origin are lost. It contains less nutritious matter

than any of the Cerealia, and, since it requires excessive moisture, and a temperature of 73°·4 at least, its cultivation is limited to countries between the equator and the 45th parallel.

Indian Corn and *Millet* are much cultivated in Europe S. of the 45th and 47th parallels, and form important articles of food in France, Italy, Africa, India, and America. Buckwheat is extensively cultivated in N. Europe and Siberia, and in central Asia; it is a native of Asia, whence it was brought into Europe in the fifteenth century.

The Cerealia afford remarkable examples of numberless varieties arising from the seed of one species. In Ceylon alone there are 160 varieties of rice, and at least 30 of millet. The endless variety which may be raised from the seed of one plant is more conspicuous in the flower garden: the rose affords above 1400; the varieties of the pansy, calceolaria, tulip, auricula, and primrose are without end, and often differ so much from the parent plant that it seems almost impossible they should have had a common origin: it seems difficult to believe that red cabbage, cauliflower, and many others should have sprung from the Brassica oleracea, so totally dissimilar from any of them, with its bitter sea green curly leaves. Fashion changes so much with regard to plants that it is scarcely possible to form even an approximation to the number known to be in cultivation: new plants are introduced from a foreign country, and are apt to take the place of some of the older, which are neglected and sometimes lost; of 120,000 plants which are known to exist on the earth, not more than 15,000 are believed to be in cultivation.

It is supposed that plants capable of bearing a great range of temperature would exist through longer geological periods than those more limited in their endurance of vicissitudes of heat and cold.

§ 7. **Forest Trees.**—Since forest trees increase by coatings from without, the growth of each year forming a concentric circle of wood round that of the previous year, the age of a tree may be ascertained by counting the number of rings in a transverse section of the trunk, each ring representing a year. Moreover the progress of the growth is known by comparing the breadth of the rings, which are broader in a favourable than in an unfavourable season, though this may depend also in some measure on the quality of the soil which the roots have come to in their downward growth. If the number of concentric rings in a transverse section has shown the age of a tree, and its girth has been ascertained by measurement, an approximation to the age of any other tree of the same kind still growing, under similar circumstances, may be determined by comparison. In this way the age of many remarkable trees

has been ascertained. The yew attains a greater age than any other tree in Europe. According to M. de Candolle this tree increases in girth the twelfth part of an inch in a year during the first 150 years, and rather less in the next 100, the increase probably decreasing progressively. By that estimate a yew at Fountains Abbey was reckoned to be 1214 years old; one at Crowhurst, in Surrey, was 1400 years old when measured by Evelyn; it has been shown by the same method that a yew at Fortingal, in Scotland, was between 2500 and 2600 years old; and one at Braburn, in Kent, must have been 3000 years old: these are the veterans of European vegetation.[1]

The cypress rivals the yew in longevity, and may perhaps surpass it. There is a cypress in the palace garden at Granada which was celebrated in the time of the Moors, and was still known in the year 1776, as Cipres della Regina Sultana, because a sultana met with Abencerrages under its shade. M. Alphonse de Candolle estimates a deciduous cypress in the churchyard of Santa Maria de Tecla, near Oaxaca in Mexico, to be 6000 years old, Zuccarini 3572, and Dr. Lindley only 870. Oaks come next in order: they are supposed to live 1500 or 1600 years. One in Welbeck Lane, mentioned by Evelyn, was computed to be 1400 years old. Chestnut trees are known to live 900 years; lime trees have attained 500 or 600 years in France; and birches are supposed to be equally durable. Some of the smaller and less conspicuous European plants perhaps rival these giants of the forest in age. Ivy is an example of this; there is one near Montpellier, 6 ft. in girth, which must be 485 years old. A lichen was watched for 40 years without the appearance of change. Eight olive trees on the Mount of Olives are supposed to be 800 years old; it is at least certain that they existed prior to the taking of Jerusalem by the Turks. There is some doubt as to the age of the largest cedar on Lebanon; it is 9 ft. in diameter, and has probably existed 800 or 900 years.

§ 8. **Marine Vegetation.**—A vegetable world lies hid beneath the surface of the ocean, altogether unlike that on land, and existing under circumstances totally different with regard to light, heat, and pressure, yet sustained by the same means. Carbonic acid is as essential, and metallic oxides are as indispensable, to marine vegetation as they are to land plants. Sea water contains a minute proportion of carbonic acid gas,[2] and something more than a twelve-

---

[1] It is worthy of remark that the trees which in our temperate latitudes attain the greatest age belong to the family of the Coniferæ, which have furnished the most ancient vegetable remains embedded in the strata that form the earth's surface, the oldest fossil plants of the Devonian and Carboniferous series belonging to trees nearly allied to Araucaria.

[2] M. Laurens has found $\frac{1}{5000}$ part of this gas in the water of the Mediterranean.

thousandth part of its weight of carbonate of lime, yet that is sufficient to supply all the shell fish and coral insects in the sea with materials for their habitations, as well as food for vegetation. Marine plants are more expert chemists than we are, for the water of the ocean contains rather less than a millionth part of its weight of iodine, which they collect in quantities impossible for us to obtain otherwise than from their ashes.

Seaweeds fix their roots to anything—to stone, wood, and to other seaweeds; they must, therefore, derive all their nourishment from the water, and the air it contains; and the vital force or chemical energy by which they decompose and assimilate the substances fit for their maintenance is the sun's light.

Marine plants, which are very numerous, consist of two groups—a jointed kind, which include the Confervæ, or plants having a thread-like form; and a jointless kind, to which belong dulse, laver, the kinds used for making kelp, iodine, vegetable glue, and all the gigantic species which grow in submarine forests, or float like green meadows in the open sea. Some species are found in every climate from pole to pole. No doubt the currents at the surface, and the stratum of uniform temperature lower down, are the highways by which these cosmopolites travel.

Marine vegetation follows a different law from that of the land, for it is neither so varied in form, so rich in colour, nor in such abundance between the tropics as in the temperate zones; and there are fewer vegetable provinces in the seas than on shore, because the temperature is more uniform, and the dispersion of plants is not so much interfered with by the various causes which disturb it on land.[1]

Marine vegetation varies both horizontally and vertically with the depth, and it seems to be a general law throughout the ocean that the light of the sun and vegetation cease together; it consequently depends on the power of the sun and the transparency of

---

[1] Professor Harvey of Dublin has divided the marine vegetation into 10 provinces:—the Northern Ocean, from the Pole to the 60° N. lat.; the North Atlantic, between 60° and 40°, which is the province of the delesserieæ and fucus proper; the Mediterranean, which is a sub-region of the warmer temperate zone of the Atlantic lying between the 40° and 23° N. lat.; the tropical Atlantic, in which sargassum, rhodomelia, corallinia, and siphonea abound; the antarctic American region, from Chili to Cape Horn; the Falkland Islands; and the whole circumpolar ocean S. of 50° S. lat.; the Australian and New Zealand province, which is very peculiar, being characterised, among other generic forms, by the fucaceæ; the Indian Ocean and the Red Sea; and the last, which comprises the Japan and China Seas. There are several undetermined botanical marine provinces in the Pacific and elsewhere.

the water; so different kinds of seaweeds affect different depths, where the weight of the water, the quantity of light and heat, suit them best. One great marine zone lies between the high and low water marks, and varies in species with the nature of the coasts, but exhibits similar phenomena throughout the northern hemisphere. In the British seas, where, with two exceptions, the whole flora is cryptogamic,[1] this zone does not extend deeper than 30 fathoms, but is divided into two distinct provinces, one to the south and another to the north. The former includes the S. and E. coasts of England, the S. and W. coasts of Ireland, and both the channels: while the N. flora is confined to the Scottish seas and the adjacent coasts of England and Ireland. The second British zone begins at low water mark, and extends below it to a depth from 7 to 15 fathoms. It contains the great tangle seaweeds, growing in miniature forests, mixed with fuci, and is the abode of a host of animals. A coral-like seaweed is the last plant of this zone, and the lowest in these seas, where it does not extend below the depth of 60 fathoms, but in the Mediterranean it is found at 70 or 80 fathoms, and is the lowest plant in that sea. The same law prevails in the Bay of Biscay, where one set of seaweeds is never found lower than 20 ft. below the surface; another only in the zone between the depths of 5 and 30 ft., and another between 15 and 35 ft. In these two last zones they are most numerous; at a greater depth the kinds continue to vary, but their numbers decrease. The seeds of each kind float at the depth most genial to the future plant: they must, therefore, be of different weights. The distribution in the Ægean Sea was found by Professor E. Forbes to be perfectly similar, only that the vegetation is different, and extends to a greater depth in the Mediterranean than in more northern seas.[2] He also observed that seaweeds growing

---

[1] The only British flowering plants that inhabit the ocean are Zostera and Zanichellia.

[2] The vegetation at different depths in the Ægean Sea is as distinctly marked as that at different heights on the declivity of a mountain. The coast plants are the Padina pavonia and Dictyota dichotoma. A greater depth is characterised by the vividly green and elegant fronds of the Caulerpa prolifera, probably the prasium of the ancients; associated with it are the curious sponge-like Codium bursa, and four or five others. The Codium flabelliforme, and the rare and curious vegetable net called Microdictyon umbilicatum, characterise depths of 30 fathoms. The Dictyomenia with stiff purple corkscrew-like fronds, and some others, go as low as 50 fathoms, beyond which no flexible seaweeds have been found. The coral-like Millepora polymorpha take their place, and range to the depth of 100 fathoms, beyond which there was found no trace of vegetable life, unless some of the minute and microscopic infusorial bodies living there be regarded as plants.—'Travels in Lycia,' by Lieutenant Spratt, R.N., and Professor E. Forbes.

near the surface are more limited in their distribution than those that grow lower down, and that with regard to vegetation depth corresponds with latitude as height does on land. Thus the flora at great depths, in warm seas, is represented by kindred forms in higher latitudes. There is every reason to believe that the same laws of distribution prevail throughout the ocean and every sea.

Seaweeds adhere firmly to the rocks before their fructification, but they are easily detached afterwards, which accounts for some of the vast fields of floating weeds; but others, of gigantic size and wide distribution, are supposed to grow unattached in the water itself. There are permanent bands of seaweed in the British Channel and in the North Sea, of the kind called Fucus filum, which grow abundantly on the western coast of the Channel: they lie in the direction of the currents, in beds 15 or 20 m. long, and not more than 600 ft. wide. These bands must oscillate with the tides between two corresponding zones of rest, one at the turn of the flood, and the other at the turn of the ebb. It is doubtful whether the Fucus natans or Sargassum bacciferum grows on rocks at the bottom of the Atlantic, between the parallels of 40° N. and S. of the equator, and, when detached, is drifted uniformly to particular spots which never vary, or whether it is propagated and grows in the water; but the mass of that plant W. of the Azores occupies an area equal to that of Germany, and has not changed its place since the time of Columbus. Fields of the same kind cover the sea in the South Pacific, near the Bahama Islands and other places, and two new species of it were discovered in the Antarctic seas.

The Macrocystis pyrifera and the Laminaria radiata are the most remarkable of marine plants for their gigantic size and the extent of their range. They were met with on the antarctic coasts two degrees nearer the S. pole than any other vegetable production, forming, with one remarkable exception, the utmost limit of vegetable life in the south polar seas. The Macrocystis pyrifera exists in vast detached masses, like green meadows, in every latitude from the S. polar ocean to 45° N. lat. in the Atlantic, and to the shores of California in the Pacific, where there are fields of it so impenetrable that it has saved vessels driven by the heavy swell towards that shore from shipwreck. It is never seen where the temperature of the water is at the freezing point, and is the largest of the vegetable tribe, being occasionally 300 or 400 ft. long. The Laminaria abounds off the Cape of Good Hope and in the Antarctic Ocean. These two species form great part of a band of seaweed which girds Kerguelen Land so densely that a boat can scarcely be pulled through it; they are found in great abundance on the coasts of the Falkland group, and also in vast

fields in the open sea, hundreds of miles from any land: had it ever grown on the distant shores it must have taken ages to travel so far, drifted by the wind, currents, and the scud of the seas. The red, green, and purple lavers of Great Britain are found on the coasts of the Falkland Islands; and though some of the northern seaweeds are not met with in the intervening warm seas, they reappear here. The Lessonia is the most remarkable marine plant in this group of islands. Its stems, much thicker than a man's leg, and from 8 to 10 ft. long, fix themselves by clasping fibres to the rocks above high-water mark. Many branches shoot upwards from these stems, from which long leaves droop into the water like willows. There are immense submarine forests off Patagonia and Tierra del Fuego, attached to the rocks at the bottom. These plants are so strong and buoyant that they bring up large masses of stone; and, as they grow slanting, and stretch along the surface of the sea, they are sometimes 300 ft. long. The quantity of living creatures which inhabit these marine forests and parasitical weeds attached to them is inconceivable; they absolutely teem with life. Of the speeies of marine plants which are strictly antarctic, including those in the seas of Tasmania and New Zealand, Dr. Hooker has identified one fifth with the British Algæ.

The higher latitudes of the Antarctic Ocean are not so destitute of vegetation as was at first believed. Most minute objects, altogether invisible to the naked eye, except in mass, and which were taken for siliceous shelled animalcules of the infusorial kind, prove to be vegetable. They are a species of the Diatomaceæ, which, from their multitudes, give the sea a pale ochreous brown colour. They increase in numbers with the latitude, up to the highest point yet attained by man, and no doubt afford food to many of the minute animals in the antarctic seas. Genera and species of this plant exist in every sea from Victoria Land to Spitzbergen, It is another of the remarkable instances of a great end being effected by small means; for the siliceous shells of this antarctic vegetation are forming a submarine bank between 76° and 78° S. lat., and from the 165th to the 160th W. meridian.

Great patches of Confervæ are occasionally met with in the open seas. Bands several miles long, of a reddish brown species like chopped hay, occur off Bahia, on the coast of Brazil; and different species are common in the South Pacific Ocean.

CHAPTER XXX.

DISTRIBUTION OF INSECTS.[1]

§ 1. **Species, Uses, &c., of Insects.**—Above 150,000 species of insects are known in public and private museums; some with wings, others without; some are aquatic, others are aquatic only in the first stage of their existence; and many are parasitical.

Naturalists have lately found blind insects of various genera in the great subterranean caves of Europe and America. Some land insects are carnivorous, others feed on vegetables; some of the carnivorous tribe live on dead, others on living, animals, but they are not half so numerous as those that live on vegetables. Some change the kind of food as they grow from larva to perfect insect; in their first stage they eat animal food, and vegetables when they arrive at their perfect state.

Insects maintain the balance among the species of the vegetable creation by preventing the tendency that plants have to encroach on one another. The stronger would extirpate the weaker, and the larger would destroy the smaller, were they not checked by insects which live on vegetables. On the other hand, many plants would be extirpated by insects were these not devoured by other insects.[2]

Insects increase in number of species and variety of forms from the poles to the equator: in a residence of 11 months in Melville Island, Sir Edward Parry found only 6 species, because lichens and mosses do not afford much nourishment for the insect tribes,

---

[1] The great division of the animal kingdom of the *Arthropoda*, to which insects belong, consists of the following four classes, the first three breathing by air-vessels (tracheæ) or air-pouches :—

1. *Insects.*—Head distinct; three divisions of the body, viz. head, thorax, and abdomen; three pairs of legs and, in general, one or two pairs of wings.
2. *Myriapoda.*—Head distinct; 24 or more pairs of legs, no wings.
3. *Arachnida* or Spiders.—Four pairs of legs, head and thorax united, no antennæ or feelers, no wings.
4. *Crustacea*, as Crabs, Lobsters, &c.—Respiration by means of branchiæ or gills, and in general aquatic, five or seven pairs of legs.

[2] Perhaps one of the greatest checks on the propagation of insect life is from insects themselves, many species depositing their eggs on the larvæ of others, which in their development destroy the animal on which they have been deposited. That most destructive insect to the vine, the Pyralis vitis, is a very remarkable instance of this, some dozen species of insects depositing their eggs on it in its incomplete state, thus keeping down the number of one of the greatest plagues in wine producing countries.

though it is probable that every other kind of plant gives food and shelter to more than one species; it is even said that 40 different insects are quartered upon the common nettle. Beetles are probably an exception to the law of increase towards the equator, as they seem to be more numerous in species in the temperate regions of both hemispheres than in tropical countries. The location of insects depends upon that of the plants which yield their food; and, as almost each plant is peopled with inhabitants peculiar to itself, insects are distributed over the earth in the same manner as vegetables; the groups, consequently, are often confined within narrow limits, and it is extraordinary that, notwithstanding their powers of locomotion, they often remain within a particular compass, though the plants, and all other circumstances in their immediate vicinity, appear equally favourable for their habitation.

§ 2. **Different insects under the same parallels of latitude; barriers to distribution of insects, &c.**—The insects of N. Asia belong to a great extent to the same genera as those of Europe; those of the United States differ specifically from European species, though they often approach very near to the same forms. South America is as peculiar in its insect fauna as it is in its mammalia, and the tropical portion has a distinct set of forms from that of its S. extremity. The opposite tropical zone of Africa differs widely in the same respect from South America, although not much inferior in the number and variety of its species and genera. In fact, under the same parallel of latitude, countries similar in soil, climate, and all other circumstances present the most striking differences in their insect tribes, even in those that live on animal substances.

Though insects are distributed in certain limited groups, yet most of the families have representatives in all the great regions of the globe, and some identical species are inhabitants of countries far from one another. The Pyrameis cardui, or 'Painted Lady Butterfly,' ranges almost all over the world; and being a species which never could have been conveyed by man, its wide distribution must be due to its great powers of migration. The number of species of similar extended distribution is very limited, as species and genera here, as in the larger animals, are confined to definite areas. Being immensely more abundant and more definite in their specific characters, insects, as massed in large collections, afford clearer indications of the geographical limits of faunas and the biological character of countries than any other class of animals.

Mountain chains are a complete barrier to insects, even more so than rivers: not only lofty mountains like the Andes divide the kinds, but they are even different on the two sides of the

Col de Tende in the Alps. As with plants, they have their area of distribution and within the area their peculiar *station* or locality in which they are found. Thus each soil has kinds peculiar to itself, whether dry or moist, cultivated or wild, meadow or forest. Stagnant water and marshes have their separate species; some live in water, some run on its surface, and every water plant affords food and shelter to many different kinds. Insects sometimes multiply suddenly to an enormous extent, and decrease as rapidly and as unaccountably.

Temperature, by its influence on vegetation, has an indirect effect on the insects that are to feed upon plants, and extremes of heat and cold have more influence on their localisation than the mean annual temperature. Thus in the polar regions the mosquito tribes are more numerous and more annoying than in temperate climates, because they pass their early stages of existence in water, which shelters them, and the short but hot summer is genial to their brief span of life.

In some instances *height* produces the same effect in the distribution of insect life as difference of latitude. The Parnassius Apollo, a butterfly native in the plains of Sweden, is also found in the Alps and the Pyrenees; and two or three closely allied species in the Himalayas. The Parnassius Smintheus, true to the habitat of the genus, is confined to the Rocky Mountains of North America. Some insects require several years to arrive at their full development; they lie buried in the ground in the form of grubs: the cockchafer takes three years to reach its perfect state, and some American species require a much longer time.

§ 3. **Conditions of development of insects.**—Insects do not attain their perfect development till the plants they are to feed upon are in a state to afford them habitation and nourishment. Hence in cold and temperate climates their appearance is simultaneous with vegetation; and as the rainy and dry seasons within the tropics correspond to our winters and summers, insects appear there after the rains and vanish in the hot months; the rains, if too violent, destroy them; and in countries where that occurs there are two periods in the year in which they are most abundant—one before and one after the rains. It is also observed in Europe that insects decrease during the heat of summer and become more numerous in autumn: the heat is thought to throw some into a state of torpor, but the greater number perish.

When a plant is taken from one country to another in which it has no congeners, it is not attacked by the insects of the country: thus our cabbages and carrots in Cayenne are not injured by the insects of that country, and the tulip tree and other magnolias are not molested by our insects; but if a plant has congeners in a

new country, the insect inhabitants will generally soon find their way to the stranger.

§ 4. **Insects which are most universally distributed.**—The *Common Fly* is one of the most universally distributed insects: it was unknown in some of the South Sea Islands till it was carried there from Europe, where it has now become a real plague in many places.

Mosquitoes, Gnats, or Culices are spread over the world more generally than any other tribe of insects; they are the torment by night and by day of men and animals from the poles to the equator; the species are numerous and their location partial. In the arctic regions the Culex pipiens, which passes two-thirds of its existence in water, swarms during the summer in myriads: the Lake Myvatn, in Iceland, takes its name from the legions of these tormentors that cover its surface. They are less numerous in Central Europe, though one very small species of mosquito, the Simulium Columbachense, appears in such clouds in parts of Hungary, that it is not possible to breathe without swallowing them in numbers: even cattle and children have been killed by them. In Lapland there is a plague of the same kind. Of all places on earth, however, the banks of the Orinoco and of other great rivers of tropical America are the most infested by this plague. The account given by Humboldt is really fearful: at no season of the year, at no hour of the day or night, can rest be found: whole districts in the Upper Orinoco are deserted on account of these insects. Different species succeed one another with such regularity that the time of day or night may be known from their humming noise, and from the different sensations of pain which their several poisons produce. The only respite is the interval of a few minutes between the departure of one gang and the arrival of their successors, for the species do not mix. On some parts of the Orinoco the air is one dense cloud of poisonous insects to the height of 20 ft. It is singular that they do not infest rivers that have dark coloured waters: each clear stream is peopled with its own particular kinds: though ravenous for blood, they would appear to be able to exist without it, as they are found in situations where no animals exist.

The *Tsetse-fly*, peculiar to certain definite areas in S. tropical Africa, is fatal to cattle; it is not found more to the N., but two very poisonous flies infest the forests of W. tropical Africa.

§ 5. **Honey Bees, Fire Flies, Scorpions, Ants, and Spiders.**—The common *Honey Bee* is the European insect most directly useful to man; it was introduced into North America not many years ago, is now spread over the new continent, and is naturalised over Australia and New Zealand. Several species of the same genus are found in S. Asia, but true honey bees are unknown in

South America and Australia, where their place is occupied by small stingless bees of an allied genus, producing inferior honey and wax.

Fire Flies are mostly tropical, yet there are four species in Europe; in South America there are many species, and so brilliant that their pale green light is seen at the distance of 200 paces: a Scolopendra, or Centipede, in Asia, is as luminous as the glowworm, and one in France is so occasionally.

The *Silkworm* was originally introduced from China, from which country and from N. India several allied species have been brought to Europe of late years with a view to utilising them in the production of silk. Some silkworms, as the Tusseh from N. India, produce a coarser thread, adapted for inferior fabrics; the Yama mai silkworm has been recently introduced into this country and into Prussia from Japan. The *Cochineal insect* is a native of tropical America; there are many species of it in other countries; the *Coccus lacca* is Indian, the *Coccus ilicis* lives in S. Europe, and there is one in Poland.

Scorpions under various forms are found in all warm climates; two or three species are peculiar to Europe, but they are small in comparison with those of tropical countries; one in Brazil is 6 inches long. As in the case of mosquitoes, the poison of the same species is more active in some situations than in others. At Cumana the sting of the scorpion is little feared, while that of the same species in Carthagena will produce, amongst other effects, loss of speech for many days.

Ants of different kinds are universally distributed. Near great rivers they build their nests above the line of the annual inundations. The insects called white ants, belonging to a different order, are so destructive to paper and clothing in South America, that Humboldt says there is not a manuscript in that country 100 years old.[1]

There are upwards of 1500 known species of *Spiders*, and of their allied arachnidæ; each country has its own, varying in size, colour, and habits, from the huge bird-catching spider of South America to the almost invisible European gossamer floating in the air on its silvery thread. Many of this ferocious family are aquatic; and spiders, with some other insects, are said to be the first inhabitants of new islands.

§ 6. **Migration of Insects.**—The migration of insects is one of the most curious circumstances relating to them: they sometimes appear in great flights in places where they never were seen

[1] At La Rochelle and some other parts of France a species of these destructive insects has become very abundant of late years.

before, and they continue their course with a perseverance that nothing can check. This has been observed in the migration of creeping insects: caterpillars have attempted to cross a stream. Countries near deserts are most exposed to the invasion of locusts, which deposit their eggs in the sand, and when the young are hatched by the sun's heat they emerge from the ground without wings, but as soon as they attain maturity they obey the impulse of the first wind, and fly, under the guidance of a leader, in a mass so dense that it forms a cloud in the air, and the sound of their wings is like the murmur of the distant sea. They take immense flights, crossing the Mozambique Channel from Africa to Madagascar, which is 120 m. broad: they come from Barbary to Italy, and a few have been seen to reach Scotland. Even the wandering tribes of locusts differ as to species in different deserts, following the universal law of organised nature. Insects not habitually migratory sometimes migrate in great numbers. In 1847, and again in 1869, lady birds (or Coccinellæ) and the bean aphis arrived in immense numbers at Ramsgate and Margate from the continent in fine calm weather, and a mass of the Pyrameis cardui flew over a district in a column from 10 to 15 yards wide for two hours successively. Why these butterflies should simultaneously take wing in a flock is unaccountable; had it been for want of food they would probably have separated in quest of it. In 1847 the cabbage butterfly passed in clouds from the coast of France to England. Dragon flies migrate in a similar manner.

§ 7. **Infusoria.**—Professor Ehrenberg discovered a new world of creatures in the Infusoria, so minute that they are invisible to the naked eye. He found them in fog, rain, and snow, in the ocean, in stagnant water, in animal and vegetable juices, in volcanic ashes and pumice, in opal, in the minute dust that sometimes falls on the ocean; and he detected 18 species 20 ft. below the surface of the ground in peat bog, which was full of microscopic live animals: they exist in ice, and are not killed by boiling water. While inquiring into the causes of the cholera which prevailed at Berlin in 1848, M. Ehrenberg discovered 400 species of living microscopic animalcules in different strata of the atmosphere, so that the air is analogous in the distribution of its inhabitants to the ocean, which has marine animals peculiar to different depths. These wonderful revelations have been since confirmed by various investigators, and more especially by the ingenious and exhaustive experiments and observations of M. Pasteur, who has demonstrated how difficult it is to exclude even the germs of life which everywhere abound in the atmosphere. This lowest order of animal life is much more abundant than any other, and new species are found every day. Examined by the

microscope they seem to consist of a transparent vesicle, and some have a tail: they move with great rapidity, and show a certain instinct by avoiding obstacles in their course; others have silicious shells. Language, and even imagination, fails in the attempt to describe the inconceivable myriads of these invisible inhabitants of the air and the earth; they have been brought up alive from enormous depths at sea, and vast plains of the ocean bed consist of their remains.

CHAPTER XXXI.

DISTRIBUTION OF FISHES, MOLLUSCA, INFUSORIA, AND MARINE MAMMALIA.

§ 1. **Character and Distribution of Marine Fauna.**—The marine fauna depends upon the heat and light of the sun, therefore it is rich in infinitely varied forms of being and brilliancy of colouring between the tropics, both of which gradually diminish in exuberance to the polar oceans, where the colouring is dull, the number of species few, but the individuals of each species exceedingly abundant. The marine fauna varies also with the depth, decreasing in number and variety of species from the surface downwards, where the water is colder, so that each depth has a corresponding latitude of the same temperature in which the species are either the same or representative. This is analogous to what is observed on land, where the temperature of the air decreases with the height above the surface of the sea, while in the ocean the temperature of the water decreases with the depth below it.

The fauna of the ocean consists of *Marine Mammalia, Fishes, Mollusca, Annulosa, Zoophytes, and Corallines.* These are distributed in nine belts which surround the globe, each of which, being under nearly the same circumstances as to climate, has in its different parts either the same or representative species, and therefore it is said to be Homozoic.[1] The intertropical ocean forms the central homozoic belt; it has 4 others on each side, of which those at equal distances N. and S. have faunas mutually representative; the two last belts are the circumpolar oceans. The lines which bound the homozoic belts are climatal, and nearly correspond with the isothermal lines on land, so they are neither parallel to one another, nor do they coincide with the parallels of latitude,

---

[1] K. Johnston's 'Physical Atlas.'

but are undulating from the effect of the warm and cold currents which come from the tropical and polar oceans. The fauna of part of the southern oceans is as yet very imperfectly known; that of the North Pacific, and especially of the North Atlantic, has been carefully studied, both as to extension and depth.

§ 2. **Description and Classification of Fishes.**—Fishes, properly so called, advance in the water by means of their flexible bodies and tail; the upper fins serve to balance them, and the lower ones assist them in turning, and also enable them to move slowly and to maintain themselves suspended and steady in a strong current. When in rapid motion their fins are folded close to the body in order to offer no resistance to the water. In flat fish, however, and all those that are broad horizontally, the fins aid considerably in their progressive motion. Most fishes are provided with an air vessel, or swimming bladder, which they can compress or expand when they wish to sink down or rise to the surface, but it is nearly wanting or rudimentary in such species as live at the bottom of the sea and rarely or never come to the surface. It is altogether wanting in the Remora, which has an apparatus for attaching itself to other fishes, chiefly different species of shark, and is carried about by them. The senses of seeing, hearing, and smelling are very acute in fishes, and most that live in deep water have very large eyes in order to collect and concentrate the small portion of light that can penetrate so far.[1]

§ 3. **Belts of Distribution.**—The *Arctic Ocean* is the first of the great zones into which it is convenient to class the distribution of marine animals. Its southern boundary is mainly determined by the direction and flow of cold currents. Its greatest breadth is between the Pole and the Gulf of St. Lawrence, and includes the Banks of Newfoundland, while its least extension is between the Pole and the extreme north of Scandinavia. The genera are not very numerous in this great ocean. But the most remarkable feature of this belt is the enormous shoals of the genus Gadus or cod that crowd the banks of Newfoundland. The cold current from the E. coast of Greenland, which unites with that from

[1] The skeletons of fishes are composed either of bone or cartilage; hence Cuvier's division of the finny tribe into osseous, or bony, and cartilaginous fishes. The fins are formed of spines or rays of bone united more or less by a thin web or membrane; some are hard and others soft; the bony fishes are subdivided into hard-finned or *Acanthopterygians*, as the perch, mullet, mackerel, &c., and the soft-finned or *Malacopterygians*, as the salmon, herring, pike, carp, cod, flat fishes, eels, &c. The cartilaginous fishes, or *Chondropterygians*, include the genera of the sturgeons, sharks, skates, lamprey, sun-fish, diodons, &c.

Davis Strait and runs along the American coast inside the Gulf Stream, is the highway by which these myriads of cod annually arrive. The quantity is so great that as many as half a million have been taken in a week by one vessel.

The second Homozoic or *Boreal belt* extends along the whole of the Norwegian coast, includes nearly all Iceland and, on the American side, stretches along the coast of Maine to Cape Cod, in Massachusetts. It is owing to the cold arctic current, which is of a much lower temperature than the Ocean, and several degrees below that of the Gulf Stream, that the markets of all the maritime towns of the United States, from Maine to Florida, are supplied with such a variety and abundance of excellent fish, while those in the Gulf Stream are very inferior on account of its warmth, for as a general rule the best fish for the table live in cold water.

The *Celtic belt* stretches along the Virginian coast on the W.; it includes the seas around the British Islands, from Shetland to the N. parts of the Bay of Biscay, as well as the North Sea and the Baltic. The British Islands lie between two great provinces of fishes, one on the S., the other on the N., from each of which we have occasional visitors. The tunny, torpedo, pilot fishes, and various species of sharks, come at times from our southern neighbourhood, and some years ago a great number of the tropical Bonito and Albicore arrived by the Gulf Stream, off the coasts of Cornwall and Devonshire, committing great devastations among the shoals of pilchards. In the month of February enormous quantities of cod arrive from the N., along the coast of Norway; the shoals are often many yards deep, and so closely crowded together that the sounding lead can hardly pass between them; 16,000,000 have been caught in one place in a few weeks. These shoals are on their way to the Dogger Bank, a rich fishing ground in the North Sea, from whence the markets of England and N. France are supplied with a great variety of excellent fish. But the group of fish peculiarly British has its centre in the Irish Sea; it is, however, mixed with others from the seas bounding the western shores of Central Europe, which form a distinct group. Herrings are characteristic of the British seas. They come in winter and are extremely capricious, frequenting a place in enormous quantities for a few years, and then forsaking it and going elsewhere: this was particularly the case in the Firth of Forth in the early part of the present century; however, they are always exceedingly abundant in the seas that surround Ireland and Scotland.[1] The Bay of Dublin is celebrated for its

---

[1] Recent investigations go far to prove that the herring is not migratory, but remains mostly at the bottom of the sea during certain months, and

haddocks—a fish found everywhere in our seas; and great shoals of pilchards and mackerel visit the Devonshire and Cornish coasts at different seasons of the year, being among the number of gregarious and migrating fishes. Wherever the sea bed is of sand or mud round our coasts, there turbot, soles, and other flat fish abound.

The *Common Salmon* does not exist south of 45° N. lat. on the E. coast of America, and it is probably confined within similar limits on the E. coast of Asia. It is said to be an inhabitant of all the N. parts of the Old World, from the entrance of the Bay of Biscay to North Cape, and along the arctic shores of Asia and Kamtschatka to the Sea of Okhotsk, including the Baltic, White Sea, Gulf of Kara, and other inlets. Other species of the salmon tribe are plentiful in the estuaries of the rivers in Kamtschatka and on the opposite coast of America as far S. as Oregon, but they do not appear to extend to China. These delicious fish are found in vast numbers in the rapid streams of British Columbia and Vancouver Island, and in the season they afford the chief sustenance to the Indians of those countries. Salmon is so far a sea fish that it only goes up rivers to spawn, and if by chance it is prevented from returning to the sea it becomes sickly. They make extraordinary leaps over impediments of rocks and walls in order to reach a suitable place to deposit their eggs. Salmon is entirely a cold water fish, and the plan of depositing its spawn in rivers which salmon have not hitherto frequented succeeds where these rivers empty themselves into a cool sea; where they flow into a warm one, the fish may live, but will be found very indifferent for the table.

In the three preceding belts of marine life the species have been the same on both sides of the Atlantic, but that is no longer the case S. of 44° N. lat., partly on account of the depth of that ocean and also from the absence of islands. The *Lusitanian* or *Spanish belt* embraces the Bay of Biscay, the seas on the W. coasts of Spain and Africa, so far as the Azores, and extends W. to the Canaries. Pilchards abound in the Bay of Biscay, and in other places there are numerous species of mullet near the mouths of rivers; in general the fauna is similar to that in the Mediterranean.

§ 4. **Species of European Fishes.**—The late Prince Charles Lucien Bonaparte has shown that there are 853 species of European fish, of which 210 live in fresh water, 643 are marine, and 60 of the latter go up rivers to spawn: 444 of the marine species

comes to the surface at the spawning season. In evidence of this, herrings are now taken at all times of the year on the coast of Caithness, and in the Firth of Forth.

inhabit the Mediterranean, 216 are found off the British coasts, and 171 are peculiar to the Scandinavian seas; so that the Mediterranean is richest in variety of species. In it there are several peculiar sharks, the sword fish, dolphins, anchovies, and numerous species of the scomber or mackerel tribe; one of the largest of which, indeed, of all edible fish, is the tunny, for which fisheries of great commercial importance are established on the southern coasts of France, in Sardinia, Elba, the Strait of Messina, and the Adriatic. Numerous species of skate or ray are particularly characteristic of this sea, especially the torpedoes, which have the power of producing a galvanic shock, and even emitting under certain circumstances an electric spark.

The Mediterranean furnishes only two or three American species, a few in common with the Red Sea, and a smaller number still seem to be Indian. Some of these species had probably entered the Mediterranean before it was separated from the Red Sea by the Isthmus of Suez, for geological changes have had very great influence on the distribution of fishes everywhere. Although the communication with the Black Sea is so direct, there are only 27 species common to it and the Mediterranean, no doubt on account of difference of temperature in the water. The Black Sea forms a district by itself, having its own peculiar ichthyology; and the fishes of the Caspian Sea differ entirely from those in every other part of the globe. Madeira, insulated amid a great expanse of ocean, has many peculiar species; they amount in number to half of those in Britain, and nearly as many are common to Britain and Madeira as to that island and the Mediterranean, so that many of our fish have a wide range in the Atlantic. The temperature of the Mediterranean is too high to furnish good fish for the table; the best are indifferent when compared with those of our more northern latitudes.

§ 5. **The Pacific Belt; Effect of Currents on the Distribution of Fishes.**—Dr. Richardson has found that there is one great homozoic belt in the Pacific, extending 42° on each side of the equator, between the meridians including Australia, New Zealand and the Malay Archipelago, China, and Japan, in which the genera are the same; but at its extremities the arctic and antarctic genera are mingled with the tropical forms. Many species, however, which abound in the Indian Ocean, range as far N. as Japan, which no doubt travel by the Japanese current which sets in that direction. The middle portion of this belt is vastly extended in longitude, for very many species of the Red Sea, the eastern coast of Africa, and the Mauritius, range to the Indian and China Seas, to those of North Australia, and through all the Polynesian waters; in this immense belt, which embraces three fourths

of the circumference of the globe and 60 degrees of latitude, the fish are very nearly alike, the continuous chains of islands in the Pacific being favourable to their dispersion. They are remarkable for extreme beauty of colouring, which they owe to the light and heat of a tropical sun, but on account of the high temperature of the water they are of little value as objects of food. In the North Pacific the generic forms differ from those in the Atlantic and, as in that ocean, they increase in numbers and variety with the latitude. From the near approach of the American and Asiatic coasts at Behring Strait, the fish on both sides are nearly alike down to the Sea of Okhotsk on one side, and to Admiralty Inlet on the other. The Sea of Japan and the neighbouring coasts of China are frequented by fishes having northern forms, which are there said to mingle with many species common to the temperate and warm parts of the ocean, a circumstance entirely dependent on the submarine currents. The fisheries on the coasts of China and Japan rival those on the banks of Newfoundland, for in both cases cold currents run close along these coasts from the N., by which the fish arrive from the higher latitudes, while the counter current from the Pacific Drift brings the inhabitants of a warmer sea; but although these currents are in juxtaposition, it may be doubted whether the species actually mingle, on account of the difference in temperature of the two streams.

In the South Pacific Humboldt's current brings a quantity of excellent fish along the coasts of Chile and Peru, even as far as the equator. Species representative of the cod and genus Gadus generally reappear in the S. seas very like those in the northern, and the sharks of the China seas are for the most part identical with those of Australia; the cartilaginous fish to which the latter belong have a much wider range than most of the others; however, 5 genera peculiar to the seas of very high S. latitudes range throughout the whole circle of the Antarctic Ocean.

No doubt currents are the highways of the ocean by which warm water fish may travel to high latitudes, and cold water species to low, without much change of temperature; but the tropical ocean would be a sea of fire to polar fish, and yet two very remarkable Greenland genera,[1] which inhabit such deep water that they are seldom met with except when thrown up by a storm, have been discovered on the coasts of New Zealand and South Australia. Had these fish passed the tropics they must have descended to a depth of 2000 fathoms before they came to a temperature that they could probably endure. If so, marine creatures

[1] Notacanthus and Macrourus.

must be able to sustain the enormous pressure of 12,000 ft. of water, which the late deep sea soundings show that they do.

§ 6. **Fresh Water Fishes.**—With regard to fresh water fishes, most great systems of lakes have their peculiar species, as Lake Baikal; and the fishes of the great interalpine Lake of Titicaca, which amount to 7 or 8, belong to genera only found in the higher regions of the Andes. In the North American lakes there is a bony scaled fish, bearing some analogy to those of the Secondary geological epoch; there are 4 species of perch peculiar to the North American waters, but of all the species, one only, the pike, is absolutely identical with those of our European lakes and rivers; the Gilaroo trout, which is remarkable for having a highly muscular stomach, which has been compared to a bird's gizzard, is found in a few lakes of N. Ireland only. The fresh water fish of northern climates are most esteemed for the table.

Each tropical river has its peculiar species. The fresh water fish of China[1] resemble those of India in their generic forms, but not in species, and those of the Cape of Good Hope, and South America differ from those of India and China. Sea fish, in immense quantities, frequent the estuaries of rivers everywhere; the mouth of the Mississippi swarms with them, and the quantity at the mouth of the Don in the Sea of Azof is prodigious.

There are singular analogies between the inhabitants of the sea and land. Many of the Medusæ, two Corallines, the Physalia or Portuguese man-of-war of sailors, sting like a nettle when touched. A cuttle-fish at the Cape de Verd Islands changes colour like the chameleon, assuming the tint of the bottom on which it rests, as do some of our fresh water fishes. Herrings, pilchards, and many other aquatic animals, are luminous. The medusæ, or sea-nettle tribe, which are numerous in species, have also the faculty of emitting light. In warm climates, especially, the sea seems to be on fire, and the wake of a ship is like a vivid flame with the all but microscopic Noctilucæ. These luminous creatures are the glow worms and fire flies of the ocean, while the fish with great eyes that live in its dark abyss represent its bats and owls. But among terrestrial animals there is nothing analogous to the property of the Gymnotus electricus of certain South American lakes, or of the Silurus electricus of the African rivers, and the several species of torpedo of the Mediterranean, which possess the faculty of giving an electric shock by means of a very beautiful organic voltaic apparatus with which they are provided.

§ 7. **Shell Fish, Mollusca, &c.: Various Zones of**

---

[1] The Chinese fresh water fish are Cyprinidæ, Ophicephali, and Siluridæ.

Depth in the Ocean.—Besides these more active inhabitants of the deep, the ocean is the abode of myriads of living creatures: shell fish or mollusca, crustacea, star fish, sea urchins, madrepores, corallines, &c., &c., of innumerable families and species, characteristic of the different depths and homozoic belts, all of which strictly follow the law of partial dispersion; some have very wide areas of habitation, and a few genera are nearly cosmopolite.

Throughout the whole ocean the *Littoral* or *First zone of depth*, is the space included between the high water mark and the low; hence it is exceedingly variable; in some places, as in the Mediterranean, it is not more than 1 or 2 ft. deep, while in the Bay of Fundy it is 60, and in the British Channel 30 ft. On every littoral zone some species of the genera Purpura, and Littorina or Turbo, are to be met with, except in the South African and South Australian.

From the surface to more than 100 fathoms in the arctic and boreal belts there are five distinct zones of depth. The *First* or *Littoral zone*, which extends to a depth of 15 fathoms, is distinguished by the genera Littorina or Turbo, the Purpura or whelk, and the Patella or limpet; the *other four* contain various kinds of mollusca, star fish, sea urchins, sponges, corallines, and sea weeds. The most remarkable of these is an arborescent star fish which inhabits the depths of the North Atlantic, and the Comatula Europæa, belonging to the stone lily family, or crinoids, which are fixed to the rocks when young, but become detached when full grown; they are numerous in the arctic seas to the W. of Spitzbergen; one is met with in the Indo-Pacific Ocean, and a species has been found in Dublin Bay. They are the last representatives of those beautiful zoophytes which characterised the oolitic period. The larger crustacea are exceedingly numerous in this belt, especially on the rocky coasts and islands of Norway, where an extensive fishery supplies the English, Dutch, and French markets with crabs and lobsters.

The *Celtic Belt*, which includes the British seas, has *five zones* of depth, each of which has its particular inhabitants, consisting of shell fish, crustacea, corallines, and other marine animals. The *first zone*, lying between high and low water mark, is shallow in some places and 30 ft. deep in others. In all parts of the N. hemisphere it presents the same phenomena: but the animals vary with the nature of the coast, according as it is of rock, gravel, sand, or mud. In the British seas the animals of this littoral or coast zone are distributed in three groups that differ in a marked manner from one another, though many, as the whelk and turbo, are common to all. One occupies the seas on the S. shores of our islands and both Channels; a middle group has its centre in

the Irish seas and the adjacent coasts of England and Ireland. The *second zone* extends from the low water mark to a depth of from 7 to 15 fathoms below it, and is crowded with animals living on and among the sea weeds, as mollusca, star fish, sea urchins, and many zoophytes. In the *third zone*, which is below that of vegetable life, marine animals are more numerous and of greater variety. It is particularly distinguished by animals that by their union assume an arborescent form, and seem to take the place of plants—carnivorous mollusca, together with large species of radiata. It ranges from the depth of 15 to 50 fathoms. The *fourth zone* is the region of more massive corals, peculiar mollusca, and zoophytes that only inhabit deep water. This zone extends to 100 fathoms, below which there are only two kinds of shell fish and an annelid, or sea worm, but it is probable there are more if the sea were carefully sounded. Oysters abound in these seas, as well as the mussel, cockle, and periwinkle. The E. coast of America, which has few shells, has in this belt several of those which we find on the coasts of Europe; the rest are representative. This Celtic belt has received colonists from the Atlantic on one side, and from the boreal and even the arctic on the other. Those from the two latter are regarded as descendants of members of the fauna of this area as it existed before the Glacial period. The number of animals in the Celtic zone is very great.

In the Mediterranean generally there are *five zones* of depth, of which the *first* is a mere narrow strip along the coasts, in which the creatures differ according as it is rocky or sandy; but the nearly cosmopolite genera of Purpura and Littorina are found here also. The *second zone*, which descends to 15 fathoms, abounds in cuttle-fish, and has some peculiar species of Echini. The *third zone* is the region of sponges, which form articles of commerce, together with various corallines and peculiar shells. The most remarkable production of the *fourth zone*, which descends to 100 fathoms, is the red coral used for ornaments; it is obtained at considerable depths off the coast of Sicily and Sardinia, but chiefly off the N. coast of Africa, between Tunis and Algiers, and in the Grecian Archipelago. All abound in living creatures, for this sea is extremely rich and varied in its inhabitants. The observations of Professor E. Forbes in the Ægean Sea were particularly interesting. He found that from the surface to the depth of 230 fathoms there are *eight distinct zones*, each of which has its particular vegetation and inhabitants. The number of molluscs and other marine animals is greater specifically and individually between the surface and the depth of 2 fathoms than in all the 7 regions lower down taken together, and both decrease downwards to the depth of 105 fathoms; between which and the depth of 230 fathoms

only 8 species of shells were found. The changes from zone to zone are not abrupt; some of the species of an inferior region always appear before those of the region above vanish; and although there are a few species the same in some of the 8 zones, only 2 are common to all the eight.

§ 8. **Fauna of the Tropical Atlantic and Indo-Pacific Regions.**—All circumstances combine to produce a rich marine fauna on the W. side of the tropical Atlantic. The Caribbean province is the only part of that ocean in which a region of coral reefs exists; besides, it is inhabited by mollusca, articulata, and radiata, strikingly representative of the forms, but entirely different in species from those in the Indo-Pacific. The difference between the Caribbean assemblage of marine life and that in the Gulf of Mexico on the one hand, and along the extensive shores of Brazil on the other, appears chiefly to arise from the nature of the bottom of the sea. The number of species that range from Florida to Rio Janeiro is very great.

In the Indo-Pacific region the inhabitants of the several zones of depth are not yet well known, but different species of the Purpura and Littorina still succeed each other along the western coasts of the American continent; and although species of these two genera still prevail, there is a similar representative succession of species of the beautiful Haliotis, or Sea Ear, from Tasmania to Behring Strait. This noble ocean is the very realm of reef building corals; they fill it from tropic to tropic, with the exception of an area W. from the coasts of Central America, and another between North Australia and the shores of India and China. In these calm and limpid waters the madrepores and branching corals are covered with living creatures of the most varied forms and of every colour, either hanging on them like leaves and flowers, or clinging to them like mosses and lichens, while the clear sand below is covered with the singular forms and tints of the Echinodermata, or variegated like a bed of ranunculuses with the sea anemones. In these living groves brilliant green contrasts with brown, bright red, golden yellow, and purple of every shade, from the ruddy to the purest azure. The brilliant rosy, yellow, or peach coloured nullipores overgrow the decaying masses, and are themselves interwoven with the pearl-coloured plates of the retipores, resembling the most delicate ivory carvings, while close by wave the trellis-like lilac and yellow fans of the gorgonias, the milk white bells of the jelly fish float softly in the clear water, and the little fish sparkling with every gay metallic hue dart through the whole in chase of their prey. When the shades of evening fall the sea shines like the Milky Way with myriads of brilliant sparks; the microscopic medusæ and crustaceans invisible by day form the beauty of the night; and the sea

feather, vermilion in daylight, now waves in a green phosphorescent light; every part of it is luminous; even those which are dull brown now become radiant in the most wonderful play of green, yellow, and red light; and the sun fish,[1] with its silver disc 6 ft. broad, moves slightly luminous among these lesser fires.[2] The nautilus and harp are among the most beautiful of the tropical shells,—the pearl oyster, one of the most celebrated; it abounds throughout the Persian Gulf, and on the coasts of Borneo and Ceylon, and produces the finest pearls. There are other pearl bearing shells in the Pacific, especially in the Bay of Panama, and of an inferior description in the Caribbean Sea. Some shell fish are exceedingly limited in their distribution, as the Haliotis gigantea, which is peculiar to the seas S. of Australia and the shores of Tasmania. The E. and W. coasts of intertropical Africa have a totally dissimilar fauna, and the E. and W. coasts of tropical America have only one molluscous animal in common, and both differ from those in the islands of the Pacific and the Galapagos Archipelago, which last forms a distinct region. Notwithstanding the many definite marine-provinces, the same species are occasionally found in regions widely separated. A few of the shells of the Galapagos Archipelago are analogous with those of the Philippine Islands; the Cypræa moneta lives in the Mediterranean, the seas of South Africa, the Mauritius, the East Indies, China, and the South Pacific, even as far as Tahiti, and the Janthina fragilis, the animal of which is of a beautiful violet colour, floats on the surface in every tropical and temperate sea. The molluscs have a greater power of locomotion than is generally supposed. Some migrate in their state of larva, being furnished with lobes which enable them to swim freely. The larva of the common scallop is capable of migrating to distant seas; the argonauta and nautilus float or swim along the surface.

§ 9. **Marine Life of Extra-tropical Southern Latitudes.**—Before Sir James Ross's memorable voyage to the Antarctic seas, the profound and dark abysses of the ocean were supposed to be entirely destitute of animal life, now it has been proved that no part of it is uninhabited. For although the silicious microscopic shells brought up from the depths of 1000 fathoms in Erebus Bay have proved to be the exuviæ of plants and not of a shell fish, the discovery led to an investigation of the sea bed in both of the great oceans. During the soundings across the North Atlantic for the electric telegraph cable in 1857, the mud that was brought up from the bottom, at a depth of more than 3 m., was found to be in a great measure formed of microscopic calcareous shells; scarcely a

---

1 The Orthagoriscus mola.

2 Schleiden's Lectures.

grain of sand was among them. The bottom of the Gulf of Mexico and of the Gulf Stream is everywhere a mass of microscopic shells of the most delicate structure, and in a state of complete preservation, which shows that the sea is calmly tranquil at these depths. But the bottom of the ocean is now known by deep-sea soundings to be the abode of the living as well as the vast sepulchre of the dead. In sounding to ascertain the nature of the base of the North Atlantic for laying telegraphic lines, Dr. Wallich, naturalist to the expedition, found, at a depth of about a mile and a half midway between the N. of Ireland and Greenland, that 95 per cent. of the matter of the ocean bed consists of foraminifera of the group Globigerina. Mixed with these was a vast quantity of most minute bodies called Coccolites, both singly, and attached at regular distances on cell-like bodies; both are transparent and colourless, and imbedded in gelatinous matter. Bodies identical with these are found to constitute the bulk of the material of which the vast chalk deposits are formed, and Professor Huxley has discovered in the ooze brought up from the greatest depths of the Atlantic and Indian Oceans a film of living organic substance to which he has given the name of Bathybius, and which has been termed Protoplasm, the lowest form of life. Two worms or annelids were also discovered at these great depths: one that coats itself with a tube of the shells of young Globigerinæ nicely cemented together; in the other the tube is lined with a tough substance of a rich sienna colour. These seem to perforate the shells of the Globigerinæ, and, could they bore through gutta percha, it would be vain to lay a telegraphic line; but, happily, it is impervious to annelids unless they can secrete a chemical solvent: thus it is important to ascertain whether these marine insects are capable of ruining the noblest work of man.[1] The deep-sea soundings made in the summer of 1869, in the *Porcupine*, by Dr. Carpenter, Professor Wyville Thomson, and Mr. Gwyn Jeffreys, and in the *Challenger*, under the direction of Professor (now Sir) Wyville Thomson, from 1873 to 1876, have finally settled the question of the existence of living animals at great depths in the ocean. At 2435 fathoms in the Atlantic, species of Crinoids, Echinoderms, Mollusca, and Crustacea were found in a temperature of 36·5° Fahr., and *Radiolarians* were found at such depths as to lead to the belief that these creatures live all through the sea and down to its vastest depths.

§ 10. **Quantities of Animalcula in the Ocean.**—The quantity of minute animal life in the ocean exceeds all imagination. The discoloured portions of the seas generally owe their tints to myriads of minute animalcula. Dr. Poeppig mentions a stratum

[1] Dr. Wallich's Memoirs in the 'Magazine of Natural History.'

of red water, near Cape Pilares, 24 m. long and 7 broad, which, seen from the mast head, appeared of a dark red colour; on entering it it became of a brilliant purple, while the water in the wake of the vessel was of a rosy hue. The water itself was perfectly transparent, but small red masses could be discerned moving in spiral lines. The colour of the Vermilion Sea off the coast of California is no doubt owing to a similar cause; Dr. Darwin found red and chocolate coloured water, which had been before observed by Ulloa on the coast of Chile, over spaces of several square miles, full of microscopic animalcula, darting about in every direction, and sometimes appearing to explode. Professor Dana mentions, in his memoir on the 'Distribution of the Crustacea,' having sailed through an extensive area of 'bloody water' off the coast of Chile, which owed its colour to myriads of minute crustacea: he met with another instance of the same in the tropical Atlantic.

These minute forms of organic life, invisible to the naked eye, are extensively distributed throughout the ocean; the small points which shine at night are sometimes so numerous that they give a milky colour to the sea by day, but several varieties of infinitesimal creatures are intensely and extensively developed in both the polar oceans, and serve for food to the higher orders of fishes in latitudes beyond the limits of the larger vegetation, though they themselves probably live on the microscopic plant already mentioned, which abounds in all seas. In the Arctic Ocean, where the water is of a pure transparent ultramarine colour, areas of 20 or 30 sq. m. and 1500 ft. deep, are green and turbid from the quantity of minute animalcula.

The enormous prodigality of animal life supplies the place of vegetation, so scanty in the ocean in comparison with that which clothes the land; still it probably would be insufficient for the supply of the marine creation were the deficiency not made up by the superabundant land vegetation and insects carried to the sea by rivers. The fish that live on seaweed must bear a smaller proportion to those that are predaceous than the herbivorous animals on land do to the carnivorous. Fish are certainly most voracious; none are without their enemies; they prey, and are preyed upon; and there are species which even devour the live coral, hard as its coating is; nor does the coat of mail of the Mollusca and Crustacea protect them. Whatever the proportions may be which predatory fish bear to herbivorous, the quantity of both must be enormous, for, besides the infusoria, the great forests of fuci and seaweed are everywhere a mass of infinitely varied forms of animal life, either parasitical, feeding on them, seeking shelter among them, or in pursuit of others.

§ 11. **Marine Mammalia.**—The polar seas are the habita-

tions of the hugest and the most minute of the creatures whose dwelling is in the deep. They are the home of the marine mammalia, the largest of living creatures which, as their name implies, suckle their young. While fish breathe by gills which separate the air dissolved in the water from it, the marine mammalia are furnished with lungs and respire like terrestrial quadrupeds, so that they are obliged to come to the surface from time to time to inhale the air. They form two distinct families, Phocæ or seals, and Cetacea or whales.[1]

Seven species of the seal tribe live in the Arctic Ocean and the North Atlantic; but the Greenland seal, the bearded or great seal, and the Phoca leporina, are also found in the high latitudes of the North Pacific. Seals live exclusively on fish, and are seldom found at a great distance from land or ice islands; their favourite haunts are the polar oceans and desert islands in high latitudes, where they bask in hundreds on the sunny shores during the brief summer of these inhospitable regions, and become an easy prey to man, who has nearly extirpated the race in many places; 1,000,000 are killed annually in the South Atlantic alone. The common Greenland seal is 6 or 7 ft. long, with a face like that of a dog, and a large intelligent eye. It is easily tamed, and in the Orkney Islands it is so much domesticated that it follows its master, and helps him to catch fish. This seal migrates in herds twice in the year, and returns again to its former haunts. It comes to the coasts of Northern Europe and the British Islands at the time of migration, but it may be considered a constant inhabitant of our northern shores. The walrus, a grim-looking creature, with tusks 2 ft. long, bent downwards, and its nose covered with strong transparent bristles, has a body like that of a seal, 20 ft. long, with a coat of short gray or yellow hair. It sleeps on the floating ice, feeds on seaweed and marine animals, and lives chiefly in the Arctic seas, but sometimes is met with in Behring Strait, the coasts of Magdalen Island, and very rarely in the Gulf of St. Lawrence. Large herds of seals reach the coasts of Labrador on the fields of ice borne by

[1] The *Phocæ* consist of seals properly so called, without external ears, inhabiting our Northern seas; of Otariæ, or eared seals, chiefly confined to the Antarctic latitudes; and of the anomalous Trichecus, or Walrus. The *Cetacea* are subdivided into the Manatus and Dugong, which are herbivorous and live within the tropics; all the rest are predaceous; namely, Dolphins or Porpoises, the Cachalot or Spermaceti Whale, and the Whalebone Whales, or Balænidæ, to which belong the Greenland or Right Whale, the Rorquals, &c. It is no doubt contrary to all zoological rule to place mammalia among fishes, but the object of this chapter is rather to convey some idea of the inhabitants of the ocean than to follow their scientific affinities.

the currents from Davis Strait, and there they fall a prey to the fishermen who watch for the annual arrival of these 'sea meadows.' It is computed that upwards of 1,000,000 are killed every year in the N. hemisphere.

Seals abound in the Antarctic seas and the high southern latitudes. Sir John Ross found some of the islands in the Antarctic Ocean overrun by the Phoca elephantina, or sea elephant. The fur species, Arctocephalus ursinus, was also very numerous, chiefly about the Falkland Islands. At one time it frequented the southern coasts of Australia in great numbers; but this and other species have now become scarce, from the indiscriminate slaughter of old and young.

The marine cetacea consist of three groups—dolphins or porpoises;[1] the spermaceti whales, or Physeters, which live on fish, and are provided with long jaws and numerous teeth in the lower one; and whales, properly so called, which have no teeth, but are furnished with whalebone inserted in the upper jaw, the extreme filaments of which act as a kind of net to catch the small marine animals which form their principal food. The cetacea breathe by an opening in the centre of the head, called by whalers the blower, corresponding to the nose of terrestrial mammalia, and which also serves to expel the water taken into the mouth with the food, in the form of jets, which vary in height and form according to the species.

The most singular and beautiful of the dolphin tribe is the Narwhal or sea unicorn, which has a tusk of fine ivory, wreathed with spiral grooves, extending 8 or 10 ft. straight from the head; in general there is only one tusk, but there are always the rudiments of another, and occasionally both grow to an equal length. The old narwhals are white, with blackish spots; the young are of a uniform dark colour. This singular creature, which is about 16 ft. long, swims with great swiftness. Dr. Scoresby has seen 15 or 20 at a time playing round his ship in the Arctic seas, and crossing their long tusks in all directions, as if they were fencing. They live among the fields of ice between 70° and 80° N. lat. in Davis Strait, Disco Bay, and the gulfs and creeks of Greenland. Some wander as far S. as Scotland and the N. coasts of Europe, but very rarely.

The spermaceti whale, Cachalot, or Physeter, belonging to the tribe of the predaceous spouters, is one of the most formidable in-

[1] The carnivorous cetacea, with a few remarkable exceptions—the Inia Geoffroyi and others of the Upper Amazon and its tributaries, and the Platanista Gangetica of the Ganges—inhabit the ocean. The dolphin seen in the rivers of inner Africa is probably a Lamantin or Manatus.

habitants of the deep. Its average size is 60 ft. long and 40 ft. in circumference; its head, equal to a third of its length, is extremely thick and blunt in front, with a throat wide enough to swallow a man. The proportionally small swimming paws, or pectoral fins, are at a short distance behind the head; and the tail, which is in the form of a triangle, 6 or 7 ft. long and often 20 broad, with a notch between the flukes, is its chief organ of progressive motion and defence. It has a hump of fat on its back, is of a dark colour, but with a very smooth skin. These sperm whales have two nasal apertures or blowers on the top of their head, through which they throw at each expiration a succession of jets like smoke at intervals of 15 or 20 minutes, after which they toss their tails high in the air and go down head foremost to vast depths, where they remain for a considerable time, and then return again to the surface to breathe. The jet or spout is from 6 to 8 ft. high, and consists of water mixed with air expired from the lungs. This whale contains sperm oil and spermaceti in every part of its body; the latter substance, however, is chiefly in a great reservoir in its head which makes it very buoyant: ambergris is sometimes found in the inside of the body; it is an intestinal concretion, with usually the beaks of cuttle fish for a nucleus. These huge monsters, occasionally 75 ft. long, go in great herds or schools of 500 or 600. Females with their young and two or three males generally form one company and the young males another, while the old males feed and hunt singly. The sperm whales swim gracefully and equably with the upper part of the head above water; but when a troop of them play on the surface, some of these uncouth and gigantic creatures leap with the agility of a salmon several feet into the air, and fall down again heavily with a tremendous crash and noise like a cannon, driving the water up in lofty columns capped with foam. The fishery of this whale is attended with danger: not only the wounded animal, but its companions who come to its aid, sometimes fight desperately, killing the whalers and tossing them into the air with a sweep of their tremendous tails, or biting a boat in two. In 1820 the American whaler 'Essex' was wrecked in the Pacific by a sperm-whale: it first gave the ship so violent a blow that it broke off part of the keel; then, retreating to a distance, it rushed furiously and with its enormous head beat in a portion of the sides; and the crew had only just time to save themselves in the boat when the vessel filled. They often lie and listen when suspicious of mischief. No part of the aqueous globe is free from their visits; though chiefly the inhabitants of southern latitudes, they are found at the Aleutian Islands in the Pacific, in the North Atlantic, Baffin Bay, Davis Strait, the Firth of Forth, and in the estuary of the Thames; and

have even been caught in the Mediterranean and Adriatic; they chiefly live on the sepia or cuttle fish, and in the deepest parts of the warmer seas within or near the tropics.

The family of the Whalebone whales consists of the common Greenland or Right Whale, and Rorquals. These colossal inhabitants of the frozen seas feed on medusæ and other small marine animals, which they catch by means of the moveable plates and filaments of whalebone in their upper jaw. The Right Whale is from 65 to 70 ft. long, but they are so much persecuted that they probably never live long enough to attain their full growth. The head is very large, but the opening of the throat is so narrow that it can only swallow very small animals. It has no dorsal fin, the swimming paws are about 9 ft. long, and the flat tail is half-moon-shaped. It has 2 spouts or nostrils, through which it throws jets like puffs of smoke some yards high. It only remains 2 or 3 minutes on the surface to breathe and then goes under water for 5 or 6 minutes. The back and tail are velvet black, shaded in some places into grey, the rest is white; some are piebald.

The Right Whale swims slowly and is timid, and the capture of it is often attended with much cruelty on account of its affection for its young; indeed, the custom of killing the calf in order to capture the mother has caused much prejudice to the fisheries in both hemispheres. Formerly the Right Whale abounded everywhere within the Arctic circle, and was profitably fished for in the Atlantic; now it is rarely to be seen in the Spitzbergen and Greenland seas, it is scarce in Hudson Bay and Davis Strait, and is only to be met with in numbers to the N. of Lancaster Sound; and that in a few years will be fished out in its turn. The number of whale ships has been annually diminishing, and it is evident that the trade will ere long come to an end. An extensive fishing ground has been discovered by the ships sent in search of Sir John Franklin within Behring Strait; but as the whale here also is pursued in the same reckless manner by the whalers of the United States, it will likewise soon cease to be remunerative.

The whale found in such multitudes by Sir James Ross in the shallow water on the coasts of the Pacific and in the Antarctic Ocean, must be of a different species from the Right Whale, to which the tropical waters would be like a sea of fire, since it cannot endure and never enters, warm water.

There are some whales peculiar to the North Pacific. The inhabitants of the Aleutian Islands mention four species.

Rorquals are also Whalebone Whales, differing from the Right Whale by their more elongated form. The great Rorqual, or Rorqualus Borealis, from 80 to 100 ft. long, is the largest of marine animals. It is chiefly met with along the edge of the ice in the

seas around the island of Jan Mayen, between Bear and Cherry Islands, Novaia Zemlia, Spitzbergen—in fact, between 70° and 76° N. lat; and in open seasons it reaches as high as 80°; nevertheless it travels to lower latitudes in pursuit of herrings, and other fish, and is occasionally seen off and in the Firth of Forth. It had been caught on the coast of Norway as early as the year 890, and probably long before. The first northern navigators were not attracted by the whale as an object of commerce, but stumbled upon it in their search for a N.W. passage to the Pacific. The lesser Rorqual lives in the rocky bays of Greenland in summer, and is found on the coasts of Iceland, Norway, the Hebrides, and along the coasts of Scotland. The number of whales of all kinds that occasionally visit the Firth of Forth is very remarkable; the author has frequently seen several spouting at the same time, when shoals of herrings were coming up this estuary. There may be another reason for their visits. When a whale feels itself uncomfortable from the number of parasitical animals, chiefly of the Barnacle tribe, that have attached themselves to its skin, it rolls and tumbles about in the brackish water in the estuaries of rivers till it has got rid of them, aware that fresh water kills these animals. The bottoms of ships encumbered by marine parasites are divested of them in the same way.

The Humpback whale, or Balæna gibbosa—a rorqual 30 or 40 ft. long—is met with in the intertropical and S. regions of the Pacific and Atlantic: it is seldom molested by whalers, and is very dangerous for boats from the habit it has of leaping and rising suddenly to the surface.

None of the senses of the whale tribe are very acute: the Whalebone whales appear to have the sense of smelling more than the others; and although the Sperm whale is immediately aware of a companion being harpooned at a very great distance, it does not hear well in air, and none appear to have any voice.[1]

The Manatus and Dugong form a very small part of the cetaceous family; they are herbaceous and tropical. The Lamantin, a species of the former, lives in some rivers of Western Africa, which it ascends to a considerable distance from the sea; and another species is found in the Rivers Amazon and Orinoco, where it is known as the sea cow. Its body is round, and sometimes 12 or 15 ft. long, and it browses in herds on the herbage at the bottom of the streams.

The Dugong is an inhabitant of the eastern Archipelago and of the shallow parts of the Indian Ocean, where it feeds on seaweeds; it is more a marine animal than the Lamantin, is scarcely ever

[1] Scoresby's 'Arctic Voyages.'

seen in fresh water, and is so harmless that it allows itself to be handled. When it suckles its young it swims upright, which has probably given rise to the fable of the mermaid. This animal, like the Lamantin, will sacrifice its life for its young, and is hence held as a type of maternal affection among the Malays.

The Manatus Septentrionalis, or *Rhytina*, which formerly frequented the Arctic seas of N. Asia, probably one of the herbivorous cetacea, is supposed to be extinct.

CHAPTER XXXII.

DISTRIBUTION OF REPTILES.

§ 1. **Partial Distribution of Reptiles over the Globe.**—Reptiles, more than any other class of animals, show the partial distribution of animated beings, owing to their inability to travel to any great distance; and as they inhabit deserts, forests, and uncultivated ground, they have been little disturbed by man, who has only destroyed some individuals, but has not diminished the number of species, which, however, is small in comparison with those that existed in the Secondary geological periods. Of the mammalia but few hybernate, or fall into a torpid state in winter, such as the bear, marmot, dormouse, &c. Their fat supplies the carbon consumed by the oxygen during their feeble and imperceptible respiration, and is wasted by the time the warm weather returns, which rouses them from their lethargy, thin and attenuated. But reptiles, being colder blooded, bury themselves in the ground, and hybernate during the winter in cold and temperate climates. In hot countries they fall into a state of torpor during the dry season, so that they have no occasion to wander either on account of temperature or want of sustenance; and the few that do migrate in quest of food always return to their old haunts. As the blood of reptiles, from the peculiarity of their circulation, receives only a small part of the oxygen they inhale, little heat and strength are generated, and they are for the most part sluggish in their motions, which, however, are more varied than in mammalia; but as some reptiles, such as tortoises and lizards, breathe more frequently than others, there are consequently great differences in their powers of locomotion and sensibility.

§ 2. **Classification of Reptiles.**—The class of reptiles is divided by Dr. Günther into 5 orders, viz., *Ophidia* (serpents),

Lacertilia (lizards), *Rhyncocephalina* (the Hatteria), *Crocodilia* (crocodiles), and *Chelonia* (tortoises). With very few exceptions, all reptiles are oviparous, or produce their young from eggs; they partake of both terrestrial and aquatic forms, and many are amphibious; they all increase in numbers towards the equator, and few live in the colder latitudes; but they can endure a cold winter better than a cool summer. The extreme southern limit of reptiles, so far as it is known, is in 50° S. lat., where a species of frog was found on the banks of the River Santa Cruz.

The number of species of reptiles in the torrid zone is at least double that in the temperate; Australia has fewer than Europe, and of all places in the Old World, Java is perhaps the richest in animals of this order. America possesses more than half of all the species known, the maximum being in Brazil, but every one of them is peculiar to the New Continent.

§ 3. **The Ophidia, or Serpents.**—*Serpents* are met with in all hot and temperate countries, but they abound most in the intertropical regions. They are most numerous in the islands of the Indian Archipelago; whilst in those of the Pacific they are few. Java contains 56 species, a greater number comparatively than is found in any other country of a similar extent; while in Borneo there are much fewer. Those in Japan are peculiar to this group of islands. Wherever innocuous snakes exist, there also are some of the venomous kinds, but they are fewer specifically and individually. Only about one fifth of the species of serpents are venomous, although that proportion is not everywhere the same. In sterile, open countries, the proportion of venomous snakes is greater than in those that are covered with vegetation. Thus, in Australia, 7 out of 10 species are poisonous; and in Africa, one of every two or three is noxious. In general, however, the number of harmless individuals is 20 times as great as the number of the poisonous.

The 3 groups of venomous serpents are the *Colubriform* or *Adder shaped snakes*, the *Triangular headed*, and *Sea serpents*.

The *Adder formed* snakes are divided into several genera. The Elaps are slender like a cord, with a small head and of brilliant colours. There are four species in South America, of which two are confined to Guiana, and one to Surinam, while the other is found everywhere from Brazil to Carolina. There is only one in Africa, 3 in Australia, and the rest are in limited districts in tropical Asia, especially in Sumatra and Java; and an entire genus is found only in India and the Islands of Ceylon and Java. The hooded snakes (or Cobra di capello) are the best known of this family, especially the spectacled or dancing snake of the Indian jugglers, which is common from Malabar to Sumatra: 2

other species are peculiar to Sumatra and Java. The 3 or 4 African species are chiefly met with at the Cape of Good Hope and on the Gold Coast: but the most celebrated is that generally known as the Egyptian asp, which has been tamed by jugglers in ancient and modern times, and is frequently figured on the Egyptian monuments: it derives some of its celebrity from having been the supposed cause of Cleopatra's death. Two of the genus inhabit Australia, one of which is hooded, but is of a different species from that of India.

The second venomous group consists of the *Triangular headed serpents,* rattlesnakes, and vipers. The first are of a hideous aspect—a large head, like a heart, broad at the base: a wide mouth, with hooked poisonous fangs strongly developed. They quietly watch their prey till it is within reach, then dart upon it, and inflict the deadly wound in a moment. The yellow viper of the French West Indian Islands, the *Trigonocephalus lanceolatus,* is one of the most dangerous snakes known. One species in the Old World occurs from Ceylon to the Philippine Islands: another is a native of Sumatra, Timor, and Celebes: 2 are confined to Java alone. Ceylon, Sumatra, Japan, and Tartary have each a peculiar species of this group.

The *Crotali,* or rattlesnakes, are all American—2 live in the warmer districts of the N. states, and 2 in the intertropical regions of South America. One of the latter, however, has a hard horn at the end of its tail, instead of a rattle, and sometimes grows to the length of 10 ft., being, with the Trigonocephalus, the longest of the venomous ophidians.

Vipers extend farther N. than any other of the noxious tribe: 2 are Asiatic, though one is also common to Africa, which, however, has 4 peculiar to itself. The only venomous serpents in Europe are 3 species of viper, one of which extends into Asia and Africa. The common viper inhabits all Central Europe and temperate Asia, as far as Lake Baikal, in the Altaï Mountains: it is also found in England and Sweden and the N. of France, but does not cross the Alps, beyond which it is replaced by a distinct species frequenting dry soils in the S.E. of Europe, and which alone is met with in Styria, Greece, Dalmatia, and Sicily; and the Aspic viper, which lives on rocky ground, inhabits France between the Seine and the Pyrenees, Switzerland, Italy, and Sicily.

There are 19 families of *innocuous serpents,* embracing many species. They are mostly terrestrial, and their species are very limited in their domicile, the greater number being confined to some of the islands of the Indian Archipelago, Ceylon, or to circumscribed districts in tropical Asia, Africa, and America.

Nine or 10 species are European, some of which are also found in Asia and Africa.

Tree serpents of various genera live only in the great tropical forests of Asia and especially of America. They are long and slender, the head for the most part ending in a sharp point, and generally green, though there are some of brighter colours: many of these serpents are fierce, though not venomous: some feed on birds, which they watch, hanging by the tail from a bough.

In all temperate and warm countries abounding in lakes and rivers fresh water snakes are numerous; some live entirely in the water, but they mostly inhabit the banks near it; they are excellent swimmers, and may be seen crossing lakes in shoals. America is particularly rich in these aquatic species, there are several in Asia, but they are rare in Africa, and none have yet been discovered in Australia.

The genus *Boa*[1] is peculiarly American. The boa constrictor, generally from 9 to 15 ft. long, lives in the great tropical forests of South America, where it often watches its prey, hanging by the tail from the boughs of trees. Two of smaller size have similar habits, and 2 are semi-aquatic, one of which, the Anaconda, is 20 ft. long, and another 6; the latter live on the banks of rivers from the Amazon to Surinam; and a species is found at the foot of the Andes of Quito, at an elevation of 3000 ft.

Pythons are the largest snakes of the E. continent, where they represent the boas of the W.: one species, which sometimes attains the length of 20 ft., is spread from the W. coast of Africa, throughout tropical Asia, to China and Java. Another, 14 ft. long, is confined to Malacca and some of the Sunda Islands. Two others are found in the island of Timor, and one in Australia. There are only 2 species of *Acrochordi*, which, like boas and pythons, twist themselves round their victims and crush them to death: one aquatic, peculiar to Java; the other is a land snake very generally distributed from India to New Guinea.

The West Indian Islands possess the snakes of the adjoining continent of America, and some confined to themselves; many in Central America are not found elsewhere. The snakes of Madagascar are almost all peculiar to that island.

Sea snakes frequent the Indian Ocean, from the Bay of Bengal to the Philippine Islands; they never enter fresh water.

§ 4. **Crocodilia.**—Of crocodiles there are 3 families, viz., the *Crocodilidæ*, the *Alligatoridæ*, and the *Gavialidæ*. True croco-

[1] This name was formerly given to all large serpents which, lacking poison fangs, destroyed their prey by constriction. The term is now restricted to the American family of them, the Old World forms being known as *Pythons*.—*Encyc. Brit. voc. Boa.*

diles occur in Asia, Africa, and the West Indies; the oldest known species inhabits the Nile and all its tributaries, but appears to have been extirpated in the Delta. It is found in all the river systems of Soudan, Senegambia, and probably in that of the Zambesi, but there seems to be a distinct species about Sierra Leone.[1] The *Gavials*, which approach nearest to the form of certain fossil crocodiles, are Asiatic, and extend from Western Australia, through the Indian Archipelago, to all the rivers of India: there are 3 species, of which the Gavialis Gangeticus is the most celebrated; another species inhabits the Euphrates. The *Alligators or Caymans*, peculiar to the American continent and the West India islands, have a very extensive habitat; they are met with in all the rivers from 31° S. lat. through South, Central, and North America, to 32° 30′ N. lat. They are most numerous in the estuaries of the great rivers, but they are found as high as 3000 ft. at the base of the Andes of Quito, and they are known in some of the rivers of Bolivia at a much greater elevation.

The *Alligators* of the Mississippi, and of the rivers and marshes of Carolina, are more ferocious than those of South America, attacking men and animals; they only prey in the night; like all their congeners, they cannot swallow their food in the water, but they drown the animal they have caught, hide it under water till it becomes putrid, and then drag it on shore to devour it. Locality has considerable influence on the nature and habits of these animals; in one spot they are very dangerous, while in another, at no great distance, they are cowardly. Alligators are rarely more than 15 ft. long, and are seen in large herds basking on the banks of rivers: their cry is like the roar of a bull: in a storm they bellow loudly, and are said to be much afraid of some of the porpoise family that ascend the great American estuaries. The female watches her eggs and her young for months, never losing sight of them; but the male devours many of them as soon as they leave her. All animals of this class are covered with scales, which are hard, horny, often bony, and impenetrable.

§ 5. **The Lacertilia or Lizard tribe.**—*Lizards* are chiefly distinguished from crocodiles by having a long thin, forked tongue,

---

[1] The most celebrated species of this division is the crocodile of the Nile which is to be met with in the upper branch of that river, the Bahr-el-Abiad, as high as 4000 ft. above the level of the sea. Immense numbers of this animal, of every size and age, are found embalmed in the catacombs of ancient Egypt, and they are perfectly identical with the existing species, offering another proof of the important fact first announced by Cuvier, from his examination of the mummies of the ibis, &c. &c., that no animal, in its wild state, had presented the least change since the most remote historical period.

like that of the viper, by their rapid motions, smaller size, and by some peculiarities of form.

The *Monitors*, which are entirely confined to the Old Continent, have the tail compressed laterally, which enables them to swim rapidly; and they are furnished with strong sharp teeth. Many species inhabit Africa and Asia, especially the Indian Archipelago; the monitor or terrestrial crocodile of Herodotus is common on the deserts which enclose Egypt; and an aquatic species in the Nile, which devours the crocodile's eggs, is often represented on the monuments of the ancient Egyptians.

Another group allied to the monitors is peculiarly American: some of the species inhabiting the marshes in Guiana are 6 ft. long.

Lizards, properly so called, are very common; more than 63 species are European, 20 of which inhabit Italy, and one lives on the Alps at an elevation of 4500 ft.; the group of the Iguanians, which differ from them chiefly in the form of the tongue, is so numerous in genera and species, that it would be vain to attempt to follow all their ramifications, which are nevertheless distributed according to the same laws as other creatures: but the *dragons*, only found in India, are too singular to be passed over. The dragon is a lizard with wings formed by an extension of the skin, which is spread along its sides and supported by outstanding long and slender ribs, attached to the fore and hind feet, as we see in the flying squirrel amongst the mammalia, and, though they do not enable it to fly, they act like a parachute when the animal leaps from bough to bough in pursuit of insects. *Nocturnal lizards* of many species inhabit the hot countries of both continents; they are not unlike salamanders, but they have sharp claws to seize their prey with, which they can draw in and conceal like a cat. One of the species of *Gecko* climb on walls in most of the countries bordering on the Mediterranean. *Chameleons* are frequent in N. Africa; and several species inhabit different districts and islands in Asia; the only European species is found in Spain; it is also common in N. Africa.

The *Anolis*, which lives on trees, replaces the chameleon in the hot regions of South America and in the Antilles, having the property common to chameleons of changing its colour, but it is a more nimble and beautiful animal. In Australia, where everything is anomalous, there is a lizard with a leaf-shaped tail, and another with a broad erectile hood.

Two anomalous *saurians* of the genus Amblyrhynchus were discovered by Mr. Darwin in the Galapagos Islands. One peculiar to the central islands is terrestrial, and in many places it has undermined the ground with its burrows; the other is the only lizard known that lives on seaweed and inhabits the sea: it is about 4 ft. long, and hideously ugly, with feet partially webbed and a tail

compressed laterally to adapt it for swimming. It basks on the beach, and in its marine habits and food it resembles, on a small scale, the huge fossil monsters so abundant in the older beds of our British secondary formations.

§ 6. **The Chelonia: or Tortoises and Turtles.**—Tortoises are covered with a shell or buckler, but their neck, legs, and tail are free, with a wrinkled skin, so that the animal can draw its head and feet into the shell when alarmed. The head is sometimes defended by a regular shield, and the jaws, instead of teeth, have a horny covering. The upper buckler is rounded, and formed of 8 parts or plates, symmetrically, and often very beautifully, disposed; the under shell is flat, and consists of 4 pairs of bones and one in the centre. One group of tortoises is terrestrial, 2 others are amphibious, one of them living in fresh water, the other in the tropical seas.

There are more land tortoises in Africa than in all the rest of the world, both specifically and individually. They abound also in the Sunda Islands, in North and South America, and especially Brazil. There are 3 European species, of which the common Tortoise (*Testudo Græca*), which is met with in the countries bordering on the Mediterranean, is the largest, attaining as much as a foot in length: it lives on insects and vegetables, and burrows in the ground in winter. Some of the East Indian species are enormously large, above 3 ft. long, and remarkable for the beautiful distribution of their colours; certain species are peculiar to Brazil, one to Demerara, and one to North America; but perhaps the largest known species is that of the Galapagos Islands, the Testudo Elephantopus, or Test. Indica, which weighs 500 or 600 pounds.

The Chelonidæ, or sea turtles, inhabit the seas of the torrid and temperate zones, as far as the 50th parallel of latitude, some living on seaweed, and others on small marine animals. Distinct species are found in different parts of the ocean. The green turtle, of which there are many varieties, inhabits the Atlantic within the tropics; they may be seen browsing on the seaweed at the bottom of the water along the coasts: they repair at certain seasons from distances of many hundred miles in great herds to the mouths of rivers to deposit their eggs in the sand. This turtle is often 6 or 7 ft. long, and weighs 600 or 700 pounds; it is much esteemed for food, but the shell is of little value. The hawk's-bill turtle, which furnishes the tortoiseshell of commerce, is caught in different parts of the Indian Ocean, among the Molucca Islands, and on the N.W. coast of New Guinea. It is also found in the W. hemisphere, on the coasts of Haiti and of the Caiman Islands, but the shell of this variety is less valuable than that from the eastern seas.

§ 7. **Difference of Species in Reptiles of the Old and New Worlds.**—With respect to the whole order of reptiles it is worthy of remark that not one species is common to the Old and New Worlds; that those in Australia are altogether peculiar to that great continent; and that, as far as is at present known, with the exception of the Marianne Islands, there are no snakes in any of the Polynesian Islands, though the Indian Archipelago abounds in them; neither are they found in Tierra del Fuego, on the coasts bordering the Strait of Magellan, nor in the Falkland Islands.

Three species of reptiles—a lizard, and two tritons—are found in Ireland, where they must have existed before its geological separation from England.

CHAPTER XXXIII.

THE AMPHIBIA.

§ 1. **Classification and Description of the Amphibia.**—This class is divided into 3 orders, each of which is subdivided into families. The orders are *the Pseudophidia, the Batrachia Anoura*, or toads and frogs, and *the Batrachia Urodela*, or Newts. The *Batrachia Anoura* approach nearest to the nature of fishes, and form a link between aquatic and terrestrial animals. In their imperfect state of tadpoles they have tails and no feet, but when full grown they generally acquire feet and lose their tails. In that early stage they are aquatic and breathe by gills; but in a state of maturity they breathe by lungs like quadrupeds, though some of the genera always retain their gills and tails, and some never acquire feet. These animals have the power of retarding and accelerating their respiration without stopping the circulation of their blood, so that they can resist heat and cold to a certain degree—a power most remarkable in the salamander, so varied in appearance and nature, which forms part of this class. Some, as toads and frogs, imbibe a quantity of water, which is evaporated through the pores of the skin, and aids to maintain them at the temperature of the medium they live in.

§ 2. **The Batrachia Anoura.**—This order consists of several families, which have four feet, but are without tails; as frogs, hylas or rainettes, toads, pipæ, &c. *Frogs* have no nails on their toes, and their hind legs, which are webbed, are longer than the fore, and consequently better fitted for swimming and jumping. They are very numerous, including about 50 species. The *Hylas*, or tree frogs, are all of the most vivid and brilliant tints, and

several colours are frequently united on the same species. They mostly live on trees, and their feet have little cushions at the extremities of the toes, forming a kind of sucker, by means of which they can squeeze out the air, and, by the pressure of the atmosphere, they adhere firmly to the underside of the smoothest leaf, exactly on the same principle by which flies walk on the ceiling of a room. The *Bufo*, or Toad, is the ugliest of the *Batrachians*; many of them are hideous, with swollen bodies, the skin being covered with wart-like excrescences, and toes obtuse. They seldom go into water, but frequent marshy and damp places, and only crawl, whereas the frog and the hyla leap. They are less numerous than either of the other genera; about 30 species are known. The common toad is capable of being tamed, and even of showing attachment. The *Pipæ*, or tongueless toads, are of a still more disgusting form. All these creatures produce a noise from the lungs, which is exceedingly varied; they croak in concert, following a leader, and when he becomes tired another takes his place. One of the North American species of frogs croak in bands; one band begins, another answers, and a third replies, till the noise is heard at a great distance; a pause then takes place, after which the croaking is renewed. Dr. Darwin notices a small musical hyla at Rio de Janeiro, which croaks a kind of harmony in different notes.

Toads and frogs are found in almost all parts of the earth, though very unequally and very partially distributed. America has more than all other countries taken together, and Europe the fewest. Six species of frogs, one rainette, and two toads are European; and all, except four of the frogs, are also found in Asia and Africa. The *Rana temporaria* lives at the height of 7700 ft. in the Pyrenees, and near the snow line on the Alps.

None of this family exist in the Galapagos Islands, nor in any of the innumerable islands of Oceania; there are few in Australia, and these, like its quadrupeds, are peculiar to it. The absence of Batrachians from oceanic islands is one of the most interesting facts in the distribution of organic life, and is explained by the impossibility of the conveyance of the spawn by oceanic currents or in logs saturated by sea water.

The great extent of marshes, rivers, and forests, together with the heat of the climate, make America the very home of amphibia, and there they grow to a greater size than anywhere else: a great number of species of frogs, tree frogs, and toads are indigenous in that continent, not one of which is the same with those in the Old World; and most of those in South America are different from those in the northern division of that continent. All these creatures have abodes with fixed demarcations, often of small extent. The Pipa, or large toad of Surinam, is the most horrid in

appearance of the tribe; the Bufo agua of Brazil, 10 or 12 inches long, and the Rana pipiens or bull-frog of Carolina, are the largest.

§ 3. **The Batrachia Urodela,** or Newts, have tails and feet, as the salamanders, which are like lizards in their general form, having a long round or flattened tail and 4 feet. They are found in Europe, but the greater number are American. The Amphiuma, Menopoma, and Syren, possessing both lungs and gills, are American; the latter are peculiar to the marshes and rice-grounds of Carolina, and the Axolotl is only found in the great lake of Mexico. The Proteus anguinus, of a light flesh colour, with 4 little feet and a flat tail, has been hitherto met with only in the dark subterraneous caverns of Carniola.

§ 4. **The Pseudophidia** include the Cæciliæ, of which there are very few species, all inhabitants of the warm parts of Asia, Africa, and America. They have a cylindrical body, without feet, and move like serpents, thus forming a kind of link between the latter family and that of Batrachians. In South America they are supposed to live in the nests of ants.

CHAPTER XXXIV.

DISTRIBUTION OF BIRDS.

§ 1. **Classification of Birds.**—The species and genera of birds are so numerous, and there is so great uniformity in general structure and also in the details of external form, that their classification is exceedingly difficult, and consequently is very various and unsettled. For the purposes of this work, however, it will suffice to adopt the classification which arranges them under eight natural orders or groups, viz., *Birds of Prey*—or vultures, falcons, owls, &c.: *Perching birds*, by much the most numerous, comprising the songsters, &c.; *Climbers*, as parrots, woodpeckers, cuckoos, &c.; *Pigeons*; *Gallinaceous birds*, including our domestic fowls, partridges, grouse, pheasants, ostriches, &c.; *Waders*, as snipes, herons, curlews, &c.; *Web-footed birds*, as ducks, petrels, &c.; and *Struthiones* or ostriches. Next to tropical America, S. Asia is richest in species; the greatest number of birds of prey inhabit Southern America, which surpasses every country in the number and beauty of its ornithological species.

There is much similarity in the birds of the N. parts of the old and new continents, and some few species are identical. Towards the S. the forms differ more and more, till in the tropical

and S. portion of the temperate zones of Asia, Africa, and America they entirely differ, whole families and genera often being confined within very narrow limits. Some, however, are almost universally distributed, especially birds of prey, waders, and aquatic species.

§ 2. **Migratory Birds.**—Birds migrate to very great distances in search of food, passing the winter in one country and the summer in another. As in cold climates insects die or hybernate during winter, and between the tropics either perish or sleep in the dry season, so, in both cases, insect-eating birds are compelled to migrate. When the ground is covered with snow, the want of seeds forces those whose food is vegetable to seek it elsewhere; and in tropical countries the annual inundations of the rivers regulate the migrations of birds that feed on fish.

Some migrate singly, some in groups, others in flocks of thousands; and in some instances the old and the young birds travel separately. Those that fly in large flocks generally have a leader, and such as do so in smaller numbers observe a certain order. Wild swans fly in groups in the form of a wedge, wild geese in a line. Some birds are silent in their flight, others utter constant cries, especially those that migrate during night, as herons, goatsuckers, and rails, to keep the flock together.

Birds of passage in confinement show the most insurmountable uneasiness as the time of migration draws near. The Canadian duck rushes impetuously to the N. at the usual period of summer flight. The American robins, goldfinches, and hangnests, brought from Canada to the North American States when young, dart northwards, as if guided by the compass, as soon as they are set at liberty. Birds return to the same place year after year. Storks and swallows take possession of their former nests, and the times of their departure are exact almost to a day. Various European birds spend the winter in Asia Minor and N. Africa: while many natives of these countries inhabit Central Europe in summer.

The birds of passage are more numerous, both in species and individuals, in America than in any other country. Ducks, geese, and pigeons migrate in myriads from the severity of the northern winters in search of a more genial climate; and when there is a failure of grain in the south different families of birds go to the north. The Virginian partridge crosses the Delaware and goes to Pennsylvania when grain is scarce in New Jersey; but it is so heavy on the wing, that many out of the flocks fall into the river and end their journey by swimming.

The same thing happens to the wild turkey, which is caught by hundreds as it arrives wet on the banks of the Ohio, Missouri, and Mississippi. These birds are not fitted for long flight by their

structure; their bones have fewer of those air-cells which give buoyancy to the feathered tribes.[1] The number of air-cells is greatest in birds that have to sustain a continued and rapid flight. The extremes are to be met with in the swift and the ostrich—the one ever on the wing, the other never—besides, the one has exceedingly long wings, the other hardly any. The strength of the ostrich is in the muscles of its leg; while the muscles on the breast of the swift weigh more than all the rest of the body; hence it is said to fly at the rate of 100 m. an hour. The wild duck and the wild pigeon fly between 400 and 500 m. in a day. The stork, quail, and some other migratory birds do not halt till the end of their journey. Many sea-birds are never seen to rest; all birds of prey, such as the eagles, vultures, and hawks, are of strong flight, and capable of sustaining themselves at heights beyond the reach of less buoyant creatures.

§ 3. **Distribution of Arctic and European birds.**—The birds of Europe and North America are better known than those of any other part of the globe. New species are constantly being discovered in Asia, Africa, and South America.

There are upwards of 600 species of birds in Europe, many of which are distributed over Asia and N. Africa, without much apparent variation. Many of our European species are also found in North America, but nearly the whole of these latter are marine birds of our northern latitudes, which, like all sea-fowl, have a wide range.

More than three fourths of the species, and a much larger proportion of individuals, of the birds of Greenland, Iceland, and Faröe, are more or less *aquatic*, and many of the remainder are only occasional visitors. Of the few small birds, the greater number are British species: but many that reside constantly in Britain are migratory in Iceland and Faröe; all the small birds leave Greenland in winter. Waders are more numerous than land birds in the Arctic regions. The snipe and the golden plover are birds of passage; the oyster catcher remains all the year in Iceland, where it makes its nest near streams, and wages war with the crow tribe.

---

[1] The quills of birds' feathers are full of air, and the hollow cavities in their bones are so many air-cells, which they can fill at pleasure. In birds that ascend to great heights like the Condor, the air in the bones is connected with the lungs by larger openings than in other birds, to enable them to breathe freely where the air is so much rarefied. To birds of long and high flight, as in the birds of passage, length of wing is also necessary.

The Gannet or Solan goose can force air between its skin and its body, which makes it extremely buoyant on the water, and enables it to bear the cold of the stormy northern seas on which it lives.

The heron, curlew, plover, and most of the other waders, migrate ; sandpipers and the water ousel remain all the year round.

Web-footed birds, being clothed with down and oily feathers, are best able to resist the cold of a polar climate. Various species of the duck tribe live in the far N., in prodigious multitudes. The mallard, supposed to be the origin of our tame duck, is found everywhere in the Arctic lands. There are two European species of eider-duck : the true eider (*Somateria mollissima*) is widely dispersed over the islands and coasts of the North Atlantic, and all the Arctic regions in Europe and America. The second European species is the King-duck (*Somateria spectabilis*).

Cormorants, which live on fish, are universally distributed over the northern seas, but are scarcely ever eaten by the natives. The cormorant sits singly, or sometimes in flocks, on the rocks, watching the fish with its keen eye : it plunges after them, and pursues them for three or four minutes under water. *Auks* are very numerous, especially the razor billed auk ; but the great auk, which is incapable of flight from the smallness of its wings, is now nearly extinct in the northern seas. *Terns*, or sea-swallows, are seen everywhere in these seas, skimming along the surface of the water, devouring mollusca and small fish. *Gulls* of many species, and in countless thousands, are inhabitants of the Arctic regions, while the temperate and tropical seas are tenanted by the equally numerous genus Procellaria, or Petrel. No birds are more widely dispersed than this genus. They are at home and brave the storm in every latitude and in every sea.

The South Pacific and the Antarctic seas are the favourite resort of *petrels*. They take their name from the faculty they have of skimming the waves with their legs hanging down, giving them the appearance of walking on the water,[1] in which they are aided by their very large flat webbed feet and widely extended wings. The stormy petrels, consisting of several distinct species, about the size and colour of a swallow, the tempest bird or Mother Cary's chicken of the sailors, are the most widely diffused ; their flight is rapid ; they shelter themselves from the storm in the hollow of a wave, and go to land only at the breeding season.

The greater part of the marine birds of the Arctic seas are inhabitants also of the N. coasts of the continent of Europe, and visit the British islands.

Few parts of Europe are richer in birds than Britain, both in species and the number of individuals; and the larger game is so abundant, that no one thinks of eating the songsters and other

---

1 Petrel, from St. Peter.

small birds, as we see in the S. of Europe. Of the European birds, 277 species are found in our islands. It is probable that most of the British birds came from Germany before the separation of our island from the continent, and that many of short flight never reached Ireland.

There are 5 European species of *Vulture*: the *Lämmergeyer* of the Alps and Pyrenees builds its nest in the most inaccessible parts of the mountains, and is seldom seen; it lives also on the mountains of N. India, Abyssinia, and in the steppes of Mongolia. Ten species of eagle are European; one is peculiar to Italy and N. India; and few if any of them are common to America. The *Golden Eagle* is perhaps an exception; that beautiful bird, which once gave a characteristic wildness to our Scottish mountains, and the distinguishing feather to the bonnet of our highland chieftains, is now nearly extirpated, and so are some of our numerous hawks. Among others, the *Jer* or gentil falcon has been so much hunted down, that it is now rare even in Iceland, its native place: there are still a few in Scotland, and several are caught in their migratory flight over the Low Countries and trained by the expert falconers for the now nearly obsolete sport of falconry.

The *Owl tribe* is numerous, and many of them are of beautiful plumage. The *Bubo maximus*, or great horned owl, the largest of our nocturnal birds, inhabits the forests of Central and Southern Europe; it is rare in France and England, though not uncommon in Ireland and Orkney: in Italy a small owl is tamed and used as a decoy in the capture of smaller birds.

The two species of our European *Goatsuckers* migrate to Africa in winter; their peculiar cry may be heard in a moonlight night when a large flock takes wing for the journey. Our swallows go all to N. Africa: one of our kingfishers (*Alcedo hispida*) is resident; the other (*Ceryle rudis*) is a native of Lower Egypt and the shores of the Red Sea, and is only occasionally found in S. Europe.

The *Sylvidæ* have soft and pointed beaks, and feed on insects and worms; the nightingale, the robin-redbreast, the wren, the smallest of European birds, the warblers, and white-throat, belong to this family. Four species of fly-catchers are found in Europe, and five species of shrikes. The *Fringillidæ* or thick billed birds are numerous in Europe; to them belong some of our finest songsters. Compared with America the starling family are few in species, as well as the woodpeckers, of which we have 6, some very beautiful. There is only one cuckoo purely European; the other two species that visit us arrive only accidentally, and all are birds of passage. There are 4 species of pigeons: the ringdove frequents the larch forests and is permanent; the stockdove leaves

us in October; the Biset or rock pigeon, supposed to be the parent bird from which the infinite variety of our domestic pigeons has sprung, flies in flocks, and makes its flimsy nest on rocks on the sea coast. Of *Gallinaceous Birds* we possess many: the pheasant has been introduced from the adjoining parts of Asia; the capercailzie, or gigantic black grouse, for many years extinct in the British forests, but recently restored to Scotland, still inhabits many parts of Europe; in Scandinavia especially it is plentiful as far as the pine tree grows, which is nearly to North Cape, and also in the Russian forests. The hazel grouse frequents the pine and the aspen forests in Central and N. Europe, where the black-cock also is plentiful. Five species of grouse and 6 of partridges afford abundance of game; 4 of the latter are confined to the S. parts of the continent, and so are the sand grouse, which form a separate genus. They inhabit the sterile plains of Andalusia and Granada, S. Italy, and Sicily.

European *Waders* are very numerous, and among them there are species of most of the described genera; woodcocks, snipes, plovers, and curlews are very abundant, and herons of various species; there are three species of egret or crested heron, and the common heron now assembles on the tops of trees unmolested, since the progress of agriculture has rendered the country unfit for hawking. Two species of cranes, a stork, and two of ibis, are met with in Europe: a flamingo lives in the S.E. parts of the continent, and in the Maremma or plains on the W. coasts of Italy. Many of the waders, however, migrate in winter. The stork, so great a favourite in Holland, that it is specially protected, is migratory; it retires to Asia Minor and Africa, and, on the return of summer, resumes its former nest on a chimney top, breeding in both countries. About 140 species of European birds either live in the more elevated parts of the Alps, or cross them in their annual migrations. They generally take their flight by the Great St. Bernard, the pass of St. Théodule, the Simplon, and St. Gothard. Europe is particularly rich in aquatic birds; there are 3 species of wild swans, 4 of geese, and more than 30 of the duck tribe, including those that inhabit the Arctic seas.

§ 4. **Birds of Asia and the Indian Archipelago.**—European birds are widely spread over N. Asia; most of the Arctic sea-fowl frequent its N. coasts; between 50 and 60 European birds are also Siberian, and there are above 70 European species in Japan and Corea, which probably also extend to Siberia and the Altaï Mountains, and some few are identical with the birds of North America; so that a similar affinity prevails in the feathered tribes of the Arctic regions as in their vegetable productions.

Asia Minor is a country of transition, and many European birds

are mixed with those of warmer regions, as the *Halcyon Smyrnensis*, a bird with gorgeous plumage, identical with the great Bengal kingfisher so generally found in India. European birds also inhabit the Caucasus, the shores of the Caspian Sea, and Persia. Moreover, these warmer climates are the winter quarters of various European species.

Farther E. the types become more Indian; the great peninsulas on each side of the Ganges are the native countries of the most gorgeous of birds. Many species of *Kingfishers* of the brightest colouring are found here; the plumage of the *Fly-catchers* has the richest metallic lustre; and the *Shrikes*, of a sober hue in our N. latitudes, are there decked in the most brilliant colours; the *Irene* has a coat of the brightest ultramarine blue, and the *Calyptomenæ* of Sumatra and Malacca one of an equally brilliant emerald green.

The *Large beaked Climbing Birds* are singularly handsome. The small collared *Parakeet*, so easily taught to speak, has inhabited the Indian forests and the banks of the Ganges time out of mind with a host of congeners of every colour; not one species of these, or indeed of the whole parrot tribe, is common to Asia, Africa, America and Australia, nor even to any two of these great continents, except the collared species, which is found in Africa as well as India. They are vividly coloured in India, in which the numerous species of *cuckoos* rival them; several genera of birds of the cuckoo family exist nowhere else.

Southern Asia is distinguished by the variety of its *Gallinaceous Birds* and the gorgeousness of their plumage. To this country we owe our domestic fowls; and the 2 known species of peacock are wild in the woods of India and its islands. Some of the most brilliant birds of the East belong to the pheasant tribe, of which 5 species are peculiar to China and Tibet. There are various species of the pheasant in the Himalayas, the feathers of which have a metallic lustre. The gold, the silver, and Reeves' pheasant, the tail feathers of which latter are 4 ft. long, are natives of China. The *Lophophorus refulgens*, and some others of that genus, are peculiar to the mountains of N. India.

The *Pigeons* also are very splendid in their plumage; they mostly belong to S. Asia and the islands; several of those in the Birman empire are green.

It would be impossible to enumerate the beautiful birds that live in the forests of the Asiatic continent, yet those of the Indian Archipelago far surpass them in splendour of plumage; these islands, indeed, are the abode of the most gorgeously arrayed birds in existence. Even in Java and Sumatra, though most similar to India in their winged inhabitants, there are many peculiar,

especially several species of the climbing tribe and of the honey sucking kind; but the dissimilarity increases with the distance, and in New Guinea and its adjacent islands the honey sucking genera are developed in novel forms and sumptuous plumage, and the ornithology generally is more nearly allied to that of Australia.

Many genera are peculiar to India: and many others are found exclusively in the islands of the Indian Archipelago, several of which are limited to one or two islands. There we find the *Cassicans*, which resemble jays, with plumage of metallic lustre; various species of *Buceros* with large horned beaks; *Orioles* of vivid colours; the *Swallow* that builds the edible nest; numerous and splendid *Sylvias*; and many species of *Melliphagidæ* or honey sucking birds, whose tongues terminate like a brush. Several species of *Birds of Paradise* inhabit New Guinea and the neighbouring Moluccas and Aroo Islands. They are birds of passage, and change their quarters with the monsoon. The King or *Royal Bird of Paradise* has two long slender filaments projecting from the tail, ending in a curled flat web of emerald green, and the male of the green species has long flowing plumes from the sides of his body, which give him a gorgeous appearance. The pigeons are peculiarly beautiful and numerous, but limited in their abode. The two species of *Goura*, or great crowned pigeon, the largest of their tribe, are inhabitants of New Guinea. Each island has its own species of *Lories*; many *Parakeets*, *Cockatoos*, *Kingfishers*, and *Barbets* with huge beaks, are peculiar to these islands. Even the partridges have changed their dull colours and assumed the vivid hues of the tropics. Other gallinaceous species far surpass them in beauty, as the Argus pheasant. One of the *Cassowaries*, a bird akin to the ostrich, without the power of flying, but fleet in its course, has a wide range in the Melanesian Archipelago, extending from New Guinea and North Australia to New Britain.

§ 5. **African Birds.**—A great number of European birds are also inhabitants of N. Africa; and many migrate there in winter, but the birds of the central part of the continent, S. of the great desert, are quite peculiar and characteristic. Those of the W. and N.E., and at the Cape of Good Hope, are best known, the greater part of tropical Africa being still unexplored by the naturalist. It may be observed generally that the birds of S. Africa differ from, but are, with few exceptions, corresponding species with those in the W. and N.E. parts of the continent, and that the whole of Africa S. of the desert differs in species from N. Africa and from Europe.

Africa possesses at least 700 species of the *Passerine order*. Many *Kingfishers*, the most beautifully coloured of their brilliant

race, frequent the banks of the lakes and rivers: 2 species of *Hoopoes*, one of which visits Europe in summer, and the *Honey-birds* are peculiarly abundant in Africa. They abound at the Cape of Good Hope, where the nectaries of the Proteas and other plants furnish saccharine juice for their food. The *Canary Bird* is confined to the Canary Islands. Various genera of *Bush Shrikes*, many of which are remarkable for the soft and lax feathering of the lower back, are peculiar to Africa; likewise a very fine group of birds allied to the starlings, conspicuous from their brilliant and glossy plumage. The *Ox-picker* or *Buphaga*, of which 2 species are known, is also highly characteristic of African ornithology. The *Weaving Bird*, or *Ploceus textor*, is one of the most remarkable of the granivorous tribe; it dexterously weaves its nest with grass and twigs. The *Whidah Bird*, several species of *Bee-eater*, the *Colious*, and all the *Touracous* or *Plantain-eaters*, with many species of *Woodpeckers*, are found nowhere else. The *Parrots*, which are much less numerous than in Asia or South America, are of peculiar forms. One species of *Trogon* and several genera of *Barbets* are purely African, and so are some of the *Cuckoos*. Among the latter are several species of the genus Indicator, so named from indicating where the bees have placed their nests; one of these is peculiar to Abyssinia, another to the interior at the Cape of Good Hope and the forests on the Zambesi.

To Africa we are indebted for the Guinea Fowl, of which there are 6 or 7 species known: they wander in flocks of hundreds among the brushwood on the banks of rivers and lakes in all the tropical regions, and are even more abundant in Madagascar. Many species of *Gallinaceous Birds* are peculiar, especially the *Gangas*, of which there are no less than 5; some unite in coveys, and others traverse the deserts in flocks of many hundreds. These birds are much more abundant on the arid deserts of N. Africa than in Europe; the partridges in this country are represented by the francolin.

The *Ostrich* occupies the wide range of Africa and Arabia; and *Bustards*, also wanderers in the plains, are numerous: the most peculiar are the *Houbara*, and the *Otis caffra*, in S. Africa, the latter 5 ft. high, remarkable for the brilliancy of its eye.

Waders of infinite variety inhabit the rivers, lakes, and marshes —woodcocks, snipes, plovers, storks, cranes, herons, and spoonbills. The most peculiar are the Dromes and Marabous, the feathers of which form a considerable article of commerce; the cream coloured Plover, the Scopus or Ombrette, the Water Treader of Abyssinia, and the Tantalus or Curlew tribe, to which belongs the Ibis (*Ibis religiosa*), held sacred by the ancient Egyptians, so frequently found as mummies in the catacombs, and represented on their

monuments, and the recently discovered huge broad billed Heron, the *Balæniceps rex*, which inhabits the upper branches of the White Nile, where it feeds on water tortoises and lizards.

§ 6. **Birds of North America.**—Of more than 600 species of North American birds, about 100 are also found in Europe, the greater number of which are aquatic, and live on the N. coasts of both continents. The *Sea Birds* of the North Pacific and Behring Strait very nearly resemble those in the Greenland Seas and the North Atlantic; the great auk of our northern seas also exists on the North Pacific; and the large white albatross, seldom seen in the North Atlantic, frequents in immense flocks Behring Strait and the W. coasts of North America. It is met with almost everywhere in the Pacific as far as the stormy regions near the Antarctic circle. Like the petrel it is a bird of the tempest, sailing calmly on its wide-spreading wings in the most tremendous gales, and following a ship for days, seldom resting on the wave: this and the giant petrel are the largest of winged sea fowls; some measure 14 ft. between the tips of the wings.

There is no species of vulture common to the two continents, but there are *Eagles* and other birds of prey, and several *Waders* and web-footed birds: yet in their general character the birds of North America differ from those of Europe: about 80 American genera and 2 families are not found in Europe. The *Humming Birds* are exclusively American; only four species are found in the Northern States. The *Parrot family* has but one representative here, which lives in the forests of the Carolinas. It is singular that a country with so many rivers and lakes should possess only one species of *Kingfisher*. The woods are filled with many species of *Creeping Birds*, and there are numerous peculiar *Wood Warblers* and *Tyrant Fly-catchers*. *Ravens*, *Crows*, *Pies*, and *Jays* abound. The *Finch tribe* is very numerous, and there are 16 species of *Woodpeckers*, as might be expected in a country covered with forests. Of *Pigeons* there are 8 species, but individually they are innumerable, especially the *Ectopistes migratoria*, which passes over Canada and the N. States in myriads for successive days twice in the year. Our poultry yards are indebted to North America for the *Domestic Turkey*, which there ranges wild in its native woods and attains great size. There are no *Partridges*, properly speaking, but the *Ortyx*, a genus closely allied, represents them, and, of 13 American species of *Grouse*, only one probably is found in Europe. The vast expanse of water and marshy ground makes North America the favoured region of innumerable water fowls and waders. Most of the waders and granivorous birds are migratory; in winter, finding no food N. of the great lakes, where the ground is frozen upwards of 6 months in the year, they are

obliged to migrate to the S.; many, as Storks and Cranes, pass the winter in California; wild geese cover acres of ground near the sea, and when they take wing their clang is heard from afar. Even gulls and other northern sea birds repair to the coasts of California, and to the temperate shores of all the North Pacific.

It may be said generally that, with regard to the web-footed order, North America possesses species of all the genera of the Old World, and many peculiarly its own. The table-land of Mexico has some peculiar forms, and a few species of swimming birds found only in more northern latitudes.

§ 7. **Birds of South America.**—The inhabitants of the air in South America differ more from those in North America than these latter do from the birds of Europe: there are not more than 50 or 60 species common to the two continents of the W. hemisphere. South America has a greater variety of original forms than any other country; more than 200 genera with all their species inhabit that continent only: of the passerine family alone there are at least 1000 species, all peculiar to it. The *Vultures* belong to different forms from those in Europe; the Condor of the Andes is the largest; it frequents the highest pinnacles of the Andes in summer, and builds its nest at the height of 15,000 ft. and more above the sea; Humboldt saw it wheeling in circles at the elevation of 22,000 ft. It inhabits the Andes from the Strait of Magellan to 7° N. lat., but it has never been seen N. of the Isthmus of Panamá, the Californian Condor being a different and smaller bird. It roams over the plains of Patagonia even to the mouth of the Rio Negro, and at times descends from the Andes to the sea shore to feed upon dead whales; like all the vulture tribe, it possesses the faculty of discovering a dead or a dying animal from a very great distance. Although the *Condor* lives principally on dead animals, it will sometimes attack the living; its habits are those of our common vulture; its size and ferocity have been much exaggerated; the most remarkable point in its history is the great vertical extent at which it is known to live, from the level of the sea to an elevation of nearly 4 m. The *Sarcorhamphus papa*, or king of the vultures, an inhabitant of the tropical regions, is remarkable for the bright blue and vermilion colour of its bare head and neck; the black vulture lives in large flocks on the high trees in the forests of Brazil, and extends as far northwards as S. Mexico: other species prey on animals in the llanos or plains. The *Guacharo*, or Fat bird, which forms of itself the genus *Steatornis*, is the size of a common fowl, with the form and beak of a bird of prey, and is a singular instance of a nocturnal bird feeding on fruit. It shuns the daylight, and is found under the natural bridge of Pandi, near Bogota, and in the caverns of

Guadaloupe and Trinidad: incredible numbers have taken possession of the dark cavern of Guacharo in the valley of Caripe, where they are killed by thousands every year for their fat.

The *Troupials* represent our Starlings, the *Bataras* and *Becardes* our Shrikes, while the *Tanagers*, gaily coloured members of the family *Fringillidæ*, show likewise some connection with the American Wood-warbler. The *Trochilidæ*, or humming birds, are peculiarly characteristic of South America; 400 species of this group, from the size of a wren to that of a humble bee, adorn the tropical regions of Brazil and Guiana. This family is peculiarly American, and ranges from the Strait of Magellan to 38° N. lat.; it may be met with in the forests on the mountain of Orizaba at an elevation of 11,000 ft. above the sea, and some beautiful species of it at still greater heights in the Andes of Bolivia and New Granada. There are only 3 or 4 humming birds that visit the N. States, but many are permanent in Central America: in some places these birds are migratory: they come in multitudes to N. Chile in summer, and disappear in winter. In British Columbia they appear in spring immediately on the melting of the snow, when the wild Ribes burst into blossom. The *Climbing Birds*, with large bills, are mostly confined to the tropical forests, which swarm with peculiar races of toucans, parrots, and macaws. Parrots range from the Strait of Magellan to 42° N. lat., where the *Eider-duck*, which is a peculiar Arctic bird, first shows itself. There are whole families of birds in tropical America not to be seen elsewhere: as the vividly coloured *Toucan*, with its huge beak; the *Aracari*, some peculiar genera of the gorgeous *Trogons*; the *Tamatias* and *Jacamars*, which are both allied to the Kingfishers.

The *Gallinaceous Family* is totally different from that of the Old World; the Guan or Penelope, and the different species of Crax or Alectors, represent our pheasants, which they excel in size, but not in beauty of plumage; whilst the numerous species of *Tinamous* and cognate genera fill the place of the grouse, quails, and partridges of the old continent. South America furnishes 2 species of *Grallatorial Birds* of a very peculiar character—the Cariama of Brazil, like the secretary bird of the Cape of Good Hope in its form and its instinct for destroying reptiles, although belonging to a different order; and the Kamichi, which possesses a sharp triangular spur at the point of each wing, an instrument of attack and defence such as is possessed by no other bird to the same extent.

The three toed or *American Ostrich* ranges, like all its congeners, over a wide extent of country. One species, the *Rhea Americana*, is found from the forests of Brazil to the Rio Negro, which bounds the Pampas of Buenos Ayres on the S., and in some of the elevated

plains of the Peru-Bolivian Cordilleras; while the *Rhea Darwinii* roams over the plains of Patagonia to the Strait of Magellan.

The *Water Fowl* and *Waders* in this land of rivers are beyond number; millions of Flamingoes, Spoonbills, Cormorants, Herons, and Fishing Falcons follow the fish as they go up the rivers to spawn; a little snow-white heron walks on the back and over the head of the alligator while it sleeps. The water fowl are almost all peculiar. Eight or 9 genera belonging to the warm climates of the Old World are here represented by new forms, and the number of specific forms of the same genus is greater than in any other country. The splendid red Ibis, or *Ibis rubra*, inhabits Cayenne; the *Eurypyga helias*, the most beautiful of the heron tribe, from its variegated plumage, is found in the same country.

Ducks migrate in immense flocks, alternately between the Orinoco and the Amazons, on account of the greater supply of fish afforded by the floods of these rivers, which take place at intervals of 6 months from each other. Between the tropics the vicissitudes of drought and humidity have much influence on the migration of birds, because the supply of their food depends upon these atmospheric changes.

If anything more were required to show the partial location of the feathered tribes, the Galapagos Archipelago might be adduced as an example. Of 26 birds collected by Dr. Darwin, 25 were peculiar, though bearing a strong resemblance to American types; some (the *Orpheus* and the *Geospizinæ*) were even confined to particular islands. But on this comparatively recent volcanic group, only 500 m. distant from the coast of America, everything is exclusively its own—birds, plants, reptiles, and fishes; and though under the equator, none have brilliant colours.

The coasts of Peru and N. Chile, from their desert nature, are not rich in land birds, but in S. Chile there are several species of *Humming Birds*, *Parrots*, *Flamingoes*, peculiar *Ducks* and *Geese*; and there commences that inconceivable number of *Sea Birds* that swarm on the seas and coasts of the Antarctic regions. The *Black Shearwater*, or *Rhynchops nigra*, in its flights has been seen to form a dense mass 7 m. long; a particular species of *Cormorant* flies in flocks that form an unbroken line for miles. Pelicans, Terns, Petrels, &c. &c., cover the low islands and coasts of the mainland, and those of Tierra del Fuego.

In the Antarctic and S. seas *Petrels* take the place which *Gulls* occupy in our northern latitudes, and inhabit the high S. ones in prodigious numbers. Two remarkable species of this genus are found throughout the Southern Ocean on both sides of Cape Horn — the Giant Petrel (*P. gigantea*), equal to the Albatross in size, and resembling it in its mode of life—it sometimes becomes

perfectly white: and the Equinoctial Petrel (*P. æquinoctialis*), a beautiful bird as large as our domestic fowl, and of a jet-black colour. A flock of what was supposed to be the young of the Petrel Pintado, or Cape Pigeon (*P. capensis*), seen during the expedition of Sir James Ross, was estimated to have been from 6 to 10 m. long, and 2 or 3 m. broad, absolutely darkening the air during the two or three hours they were flying over the ships. The snowy petrel, a most elegant bird, never quits the ice, and consequently is seldom seen outside of the Antarctic circle. Four species of the southern *Pengûins* (*Aptenodytes*) inhabit these seas; the *A. Forsteri,* the largest of sea birds, a rare and, for the most part, solitary species, weighing from 60 to 70 pounds, lives on the pack-ice. Two other species of this genus are smaller and gregarious; they crowd in myriads the snow clad islands in the high S. latitudes; every ledge of rock swarms with them, and on the shore of Possession Island, close to Victoria Land, it is difficult to pass through this feathered multitude. They are fine, bold birds, pecking and snapping with their sharp bills at those who venture to approach them. They can scarcely walk, and, their wings being mere flappers, they cannot fly; from the position of their legs they can stand erect on land, whilst they skim along the sea, and swim with great rapidity, even under water, resembling more a fish or a seal than a bird in their movements. Two species of *Albatross* breed in the Antarctic islands; and a kind of *Skua Gull,* which robs their nests; also a goose which, like the eider-duck, lines its nest with the down plucked from its breast. A very curious bird, forming a kind of link between the gallinaceous birds and waders, the *Chionis,* or Sheath-bill, is only found near the S. extremity of the American continent: it is of a milky white, of the size of our domestic pigeon, and often takes refuge on the yards and rigging of ships off Cape Horn and Staten Land, where it lives chiefly on a small species of cuttle fish. Few land birds are met with within the Antarctic circle: there are but 7 or 8 in the Auckland Islands, mostly species common to New Zealand; among others, the Tooa or Tui, and an olive coloured creeper, the choristers of the woods. One land bird only was met with in Campbell Island.

§ 8. **Australian Birds.**—The birds of Australia are in many respects as peculiar as the quadrupeds and plants of that continent; a *White Falcon* is among its birds of prey, a *Black Swan* among its water fowl, and nearly 80 genera of other birds are entirely Australian. The *Passeres* are so peculiar that they have furnished many new genera. The *Bower Bird* (so called from the habit the male bird has of building bowers for playing places), the *Regent Oriole,* or Sericulus, of splendid black and yellow plumage, and a

great proportion of the varied family of *Honey-eaters*, are essentially Australian. Two species of *Menura*, or Lyre Bird, so called from the resemblance its outspread tail bears to the form of the ancient lyre, are the only birds of the genus, and approach the character of the gallinaceous family. Here are many new forms of *Cuckoos*, as the Coucal and the Scythrops. Of *Woodpeckers* there are none. The *Parrots, Parakeets*, and *Cockatoos* are all characteristic, especially the black cockatoo, which is found in Australia only; it is not so gregarious, but even more suspicious, than the white cockatoos, which plant a sentinel to warn them of danger. *Pigeons* and *Doves* abound; the *Black Swan* and the *Cereopsis goose* are no less peculiar among the web-footed tribe. The desert plains of this great continent are inhabited by the *Emu*, a large struthious bird, incapable of flight, like its cogener the Cassowary, and once very plentiful, but now in progress of being extirpated or driven by the rapidly extending colonists to the unexplored regions of the interior.

Two, if not more, species of the *Apteryx*, birds of the same family, still linger in New Zealand, but are on the verge of extinction; they probably owe their preservation to their nocturnal habits. This anomalous genus partakes in its zoological characters of several others: the head is something like that of the curlew, with a long, slender bill, fitted for digging into the ground for worms and grubs; the legs and feet resemble those of the common fowl, with a fourth toe like a spur behind; and the wings, if wings they can be called, are exceedingly small. In a specimen with a body measuring 19 inches, the wings, stripped of the feathers, were only an inch and a half, ending in a hard horny claw 3 inches long. These comparatively small wings are characteristic of the whole family; the Ostrich and Rhea have the largest, which, though unavailing in flight, materially aid their progress in running by serving as a kind of sail; the wings of the Emu and Apteryx are only instruments of defence: the whole tribe also defend themselves by kicking. No animals have a more remarkable geographical distribution than this family, or show more distinctly the decided limits within which they have originally been placed. These huge birds can neither fly nor swim, consequently they could not have passed through the air or the ocean to distant continents and islands. They form 5 distinct genera, to each of which very extensive and widely separated countries have been allotted: the *Ostrich* is spread over Africa, from the Cape of Good Hope to the deserts of Arabia; 2 species of the *Rhea* range over the Pampas, the plains of Patagonia, and the elevated valleys of S. Bolivia and Peru; the continent of Australia is the abode of the *Emu*; the *Cassowaries* rove over some of the large islands of the Melanesian Archipelago;

and the *Apteryx*, as stated above, dwells exclusively in New Zealand. The *Dodo*, a very large, short-winged bird, extirpated within the memory of man, inhabited the Island of Mauritius. Recent examinations of its skeleton have led some naturalists to think it akin to the Trerons, or fruit eating pigeons. The *Solitaire*, another species, also allied to the pigeons, lived on the Island of Rodriguez, one of the Mascarene group, at no remote period; the Isle of Bourbon was inhabited by two other species, all of which have become extinct; and in the Island of Madagascar a bird, exceeding in size all now living, appears to have existed at a very recent period, shells of its eggs, of ten times the capacity of those of the living ostrich, having been of late years discovered in what appears to be a very modern alluvial deposit. This bird, to which the name of *Epyornis* has been given, was one of the giants of the feathered race, living or extinct.

The remains of a very numerous group of extinct struthious birds have been discovered imbedded in the very recent deposits of New Zealand. One of its genera, the *Dinornis*, chiefly found in the N. island, consists of several species: the largest, the *D. giganteus*, attained a height of 11 ft., or double that of the tallest ostrich, another, the *Palapteryx*, almost peculiar to the Middle Island, was upwards of 9 ft. in height. From the geological position in which these bones are found, as well as from their state of preservation, they can scarcely be considered as fossil, although belonging to species which have become extinct. Professor Owen has described no less than 6 species of Dinornis, and 4 of Palapteryx; and later discoveries in the colony have added several to these numbers. No better example can be cited, as elucidating the certainty of the deductions of the comparative anatomist, than what led to the first discovery of this extraordinary group of birds. A small portion of a bone, which from its dimensions appeared to belong rather to a quadruped the size of an ox than to a bird, was submitted to Mr. Owen; he boldly pronounced it, from its structure, to belong to a bird, and of the ostrich kind—a determination that was soon abundantly confirmed by the discovery, not only of the bones of the bird, but of its eggs.

The bones of another extinct bird, perhaps a Nestor, have been found mixed with those of the Dinornis. There are 3 species of the *Nestor*; 2 in New Zealand; another, almost extinct, in Philip Island, only 5 m. in extent, is found in no other part of the world. They are allied to the curious living genus *Strigops*, something between an owl and a parrot, but more nearly allied to the latter, and are very remarkable for their nocturnal habits and for living in burrows, which they make at the roots of the fern trees. The *Notornis*, a genus supposed to have been extinct, closely allied to

the water hen, the size of a bustard, has also its ancient representative in these islands,[1] where birds did and do exist, almost to the entire exclusion of quadrupeds and reptiles: an extinct species of dog, and a still existing rat, are the only animals of the class of mammalia which shared these extensive territories with multitudes of the feathered race.[2]

The ostrich family live on vegetables; the form of those that had their home in New Zealand would lead to the conclusion that they had fed on the roots of the edible fern which abounds in that country; and as no quadruped excepting a rat is now indigenous, these birds could have had no enemy but man, the most formidable of all.

The beautiful and sprightly *Tui*, or parson bird, native in New Zealand, is jet black with a white tuft on its breast, and so imitative that it can be taught to repeat whole sentences. There are *Parrots* and *Parakeets*, vast numbers of *Pigeons*, fine *Warblers*, many small birds, and a great variety of *Waterfowl*, amongst others a cormorant, which, though web-footed, perches on the trees that overhang the streams and sea, watching for fish; and a frigate bird, that pounces on them from a great height in the air. Altogether there are about 145 species of birds that inhabit this group of islands, of which 57 are land birds, and 88 waders.

---

[1] The Notornis has been found living in the Middle Island, at Dusky Bay. Its nearest affinity is with the genus Porphyrio of the Old World.

[2] In some parts of the earth the same conditions which regulated the distribution of the ancient fauna and flora still prevail. The flora of the carboniferous epoch reminds us of that of New Zealand, where ferns and club mosses are so abundant; and the fauna of that ancient period had been representative of that which recently prevailed in these islands, since footprints of colossal birds have been discovered in the red sandstone of Connecticut.

The age of reptiles of the Wealden and other secondary periods is representative of the fauna of the Galapagos Islands, which chiefly consists of tortoises and creatures of the lizard or crocodile family; and the cycadaceous plants and marsupial animals of the oolite are representative of the flora and fauna of Australia.

The colossal birds which existed in New Zealand, almost to the entire exclusion of reptiles and quadrupeds, lasted to a very recent period.

CHAPTER XXXV.

DISTRIBUTION OF MAMMALIA.

§ 1. **Classification and General Distribution of the Mammalia.**—The Mammalia, exclusive of man, consists of 10 *orders* of animals,[1] which, however differing in appearance, agree in the one general character of suckling their young. These orders are—the *Quadrumana* animals which can use their fore and hind feet as hands, as monkeys and apes; *Chiroptera,* animals with winged arms, as bats; *Carnivora,* that live on animal food, as the lion, tiger, bear, &c.; *Rodentia,* or gnawers, as beavers, squirrels, mice; *Edentata,* or toothless animals,[2] as sloths, anteaters, and armadilloes; *Pachydermata,* or thick skinned animals, as the elephant, the horse, hippopotamus, and hog; *Ruminantia,* animals that chew the cud, as camels, lamas, giraffes, cows, sheep, deer; *Marsupialia,* possessing a pouch into which the young, born in a less perfect state than in the other families, is received after birth; *Monotremata,* mammals of low organisation allied to marsupials; and *Cetacea,* inhabiting the waters, as dolphins, cachalots, whales, manati, &c.

The animal creation, like the vegetable, varies with height above the sea, and latitude; the changes of species in ascending the Himalayas, for instance, are similar to what a traveller would meet with in his journey from an equatorial to a high latitude. The number of land mammals increases from the frigid zones to the equator, but the law is reversed with regard to the marine mammalia, which abound most in high latitudes.

Taking a broad view of the distribution of the 10 orders of

---

[1] The following more modern classifications of the Mammalia are taken from Mr. Wallace's work on the 'Geographical Distribution of Animals:'

Huxley (1869), Flower (1870)		Carus (1868)
Monodelphia	1. Primates.	1. Primates.
	2. Chiroptera.	5. Prosimii.
	3. Insectivora.	2. Chiroptera.
	4. Carnivora.	3. Insectivora.
	5. Cetacea.	6. Carnivora.
	6. Sirenia.	7. Pinnipedia.
	7. Ungulata.	12. Natantia.
	8. Proboscidea.	10. Artiodactyla.
	9. Hyraocoidea.	11. Perissodactyla.
	10. Rodentia.	9. Proboscidea.
	11. Edentata.	8. Lamnungia.
Didelphia	12. Marsupialia	4. Rodentia.
Ornithodelphia	13. Monotremata.	13. Bruta.
		14. Marsupialia.
		15. Monotremata.

[2] Or, more properly, wanting certain teeth, as the canines or incisors.

mammalia, it may be stated that the tropical forests are the chief abode of the *Monkey tribe.* Asia is the home of the ape, especially the islands of the Indian Archipelago, as far as the most easterly meridian of Timor, beyond which there are none: they abound throughout Africa from the Cape of Good Hope to Gibraltar, where the Barbary ape is found, the only place where it is met with in Europe: another species of ape inhabits the island of Niphon, the N. limit of monkeys at the E. extremity of the old continent; Madagascar is the chief home of the Lemurs, which are monkeys of lower organisation. No Quadrumana are found in Australia, New Zealand, New Guinea, and neighbouring islands E. of Celebes, Oceania, N. Asia, or extratropical America.

The *Bats* that live on fruits, forming a distinct section of the order, are met with in tropical and warm climates of the Old World, especially in the Indian Archipelago; the common bats which live on insects, and are so numerous in species as to form the principal portion of the whole family, are found everywhere except in arctic America; they are the only indigenous mammals found in remote islands, such as New Zealand. The vampire is only met with in tropical America.

Carnivorous Mammalia are distributed all over the globe, though very unequally: in Australia there are no true Carnivora; while in the tropical regions of America there are about 120, in Africa 150, and in Asia 180 species; and so rapid is their increase towards the tropical regions, that there are nearly three times as many in the tropical as in the temperate zones.

With regard to the *Gnawers* or *Rodentia*, species of the same group frequently have a wide range in the same, or nearly the same, parallels of latitude, but when they are inhabitants of high mountain ridges they follow the direction of the chain, whatever that may be, and groups confined to high latitudes often appear again at great elevations in lower ones. The *Edentata* are more particularly characteristic of South America, where there are three times as many species as there are elsewhere. The *Pachydermata* are very abundant in the old continent; they have been introduced into North America by man; in the S. part of that continent the only indigenous kinds are the tapir and various species of peccary. The *Ruminantia* abound all over the temperate and tropical countries of both continents, and three species are found as far as beyond the Arctic Circle—there are neither Ruminantia nor Pachydermata in Australia. The *Marsupialia* are confined to it and New Guinea, with a few species in the two Americas. The *Monotremata*, a singular class of quadrupeds possessing many of the attributes of birds with those of the marsupialia, belong exclusively to Australia and Tasmania.

The distribution of mammalia is governed by laws analogous to those which regulate that of plants, insects, fishes, and birds. Each continent, and even different parts of the same continent, are centres of zoological families, and the exclusive home of many distinct species and genera.

Food, security, and temperature have little influence as primary causes in the distribution of animals. The plains of America are not less fit for rearing oxen than the meadows of Europe; yet the common ox was not found in that continent at the time of its discovery; and with regard to temperature this animal thrives on the Llanos of Venezuela and the Pampas of Buenos Ayres as well as on the steppes of Europe. The horse is another example: originally a native of the deserts of Tartary, he now roams wild in herds of hundreds of thousands on the grassy plains of America, though unknown in that continent at the time of the Spanish conquest.[1] All animals, however, are not so flexible in their constitutions, for most of them would perish from change of climate. The stations which the different genera and species now inhabit must have been occupied by them as each part of the land rose above the ocean, the occupation depending on the propinquity of the stations they previously inhabited, and the absence of natural barriers; and because they have found in these stations all that was necessary for their existence many have never wandered from them, notwithstanding their powers of locomotion; while others have migrated, but only within certain bounds.

Instinct leads animals to migrate when they become too numerous: the rat in Kamtschatka, according to Pennant, sets out in spring in great multitudes, and travels 800 m., swimming over rivers and lakes; and the Lapland marmot or lemming, a native in the Kiölen Mountains, migrates in great numbers, once or twice in 25 years, to the W. Ocean, which they enter and are drowned; other bands go through Swedish Lapland, and perish in the Gulf of Bothnia. Thus nature provides a remedy against the over increase of any one species, and maintains the balance of the whole creation. A temporary migration for food is not uncommon in animals. The wild ass, or Onagra, a native of the deserts of Great Tartary, in summer lives to the E. and N. of the Lake of Aral, and in autumn migrates in great numbers to Persia, and even to the high plains of N.W. India.[2] The ruminating animals

---

1 There exist, however, remains of many fossil species of horse in several parts of South and North America, contemporaneous with the mastodons and extinct gigantic Edentata of that continent.

2 The wild ass is frequent in the plains of Sindh and Baluchistan, where it is known by the name of Gorkhar. There is some doubt as to its being

that dwell in the inaccessible parts of the Himalayas and the Andes descend to their lower declivities in search of food in winter; and for the same reason the reindeer and musk ox leave the Arctic snows for a more S. latitude.

The Arctic regions form a district common to Europe, Asia, and America. On this account the animals inhabiting the N. parts of these continents belong to the same species, or to forms very similar; in fact there is no genus of quadrupeds in the Arctic regions that is not found in the two great continents. In the temperate zones of Europe and Asia, which form an uninterrupted region, identity of species is occasionally met with, but for the most part marked by such varieties in size and colour as might be expected to arise from difference of food and climate. The same genera are sometimes found in the intertropical parts of Asia, Africa, and America, but the same species very rarely, if ever; much less in the S. temperate zones of these continents, where nearly all the animals are different, whether birds, beasts, insects, or reptiles; but in similar climates tribes of forms in many respects analogous replace one another.

Europe has no family and no order peculiarly its own, and many of its species are common to other countries; consequently the great zoological districts,[1] when the subject is viewed on a broad scale, are N. Europe and Siberia, S. Asia, Africa, North and South America and Australia; but in each of these there are smaller districts, to which particular genera and families are confined. Yet when regions of similar climate and vegetation

---

the same species as the Kiang of the mountainous regions of the Himalayas and Tibet, where the latter has been seen as high as 18,600 ft. above the level of the sea.

[1] The zoological regions adopted by Mr. Wallace in his book on the 'Geographical Distribution of Animals' are as follows:

Regions	Sub-regions
I. PALÆARCTIC .	1. North Europe. 2. Mediterranean. 3. Siberia. 4. Manchuria or Japan.
II. ETHIOPIAN . .	1. East Africa. 2. West Africa. 3. South Africa. 4. Madagascar.
III. ORIENTAL. . .	1. Hindustan. 2. Ceylon. 3. Indo-China. 4. Indo-Malaya.
IV. AUSTRALIAN . .	1. Austro-Malaya. 2. Australia. 3. Polynesia. 4. New Zealand.
V. NEOTROPICAL .	1. Chili. 2. Brazil. 3. Mexico. 4. Antilles.
VI. NEARCTIC . . .	1. California. 2. Rocky Mountains. 3. Alleghanies. 4. Canada.

are not separated by lofty mountain chains, or other great barriers, the faunas are in most cases blended together on the confines between the two districts, so that there is not a sudden change.

§ 2. **European Quadrupeds.**—The character of the animals of temperate Europe has been more changed by the progress of civilisation than that of any other quarter of the globe. Many of its original inhabitants have been extirpated, and new races introduced; but it seems always to have possessed various animals capable of being domesticated. The *Wild cattle* in the parks at Hamilton and Chillingham are the only remnants of the ancient inhabitants of the British forests, though they were spread over Europe, and perhaps were the parent stock from which the European cattle of the present time are descended; the *Aurochs* (Urus), an animal nearly extinct, and found only in the forests of Lithuania, represents the Bison of North America, and is untameable. Both are supposed to have come originally from Asia. The *Mouflon*, which exists in Corsica and Sardinia, is by some supposed to be the parent stock of our domestic sheep. The *Hog*, the *Goat*, the *Red* and *Fallow Deer* have been domesticated, and also the *Reindeer*, which cannot strictly be called European, since it also inhabits the N. regions of Asia and America. Our domestic cat is a European species in its wild state. Altogether 8 or 10 species of our domestic quadrupeds have sprung from native animals.

A remarkable uniformity prevails in the organisation and instincts of each species of animal in its wild state. Many adapt themselves to change of climate; after some generations their habits and organisation alter to suit the new condition in which they are placed; bnt domestication is the cause of all our tame and useful animals; by high cultivation and training great changes have been produced in form; and in some instances habits and powers of perception are produced, approaching to reason, which remain hereditary as long as the breed is unchanged.

There are still about 180 wild quadrupeds in Europe: 45 of these are also found in W. Asia, and 9 are common to N. Africa. The most remarkable are the *Reindeer*, *Elk*, *Red* and *Fallow Deer*, the *Roebuck*, *Glutton*, *Lynx*, *Polecat*, some species of *Wild Cats*, the *Common* and *Black Squirrels*, the *Fox*, *Wild Boar*, *Wolf*, the *Black* and the *Brown Bear*, several species of *Weasels* and *Rodents*. The *Otter* is common, but the *Beaver* is now met with only on the Rhine, the Rhone, the Danube, and some other large rivers; *Rabbits* and *Hares* are numerous; the *Hedgehog* is very generally distributed; the *Porcupine* in S. Europe only; the *Chamois* and the *Ibex*, or *Bouquetin*, in the Alps and Pyrenees. Many species of these animals are widely distributed over Europe, generally with variations in size and colour. The chamois of the Alps and

Pyrenees, though of the same species, is slightly changed in appearance; the fox of the most N. parts of Europe is larger than that of Italy and of the S., with a thicker fur, and of somewhat different colour, depending on climate.

Some animals never descend below a certain height, as the ibex and chamois, which live at greater elevations than any of our European quadrupeds, being usually found between the region of trees and the line of perpetual snow, which is about 8900 ft. on the S., and 8200 on the N. declivities of the Alps. The red deer does not ascend beyond 7000 ft., and the fallow deer not higher than 6000, above the level of the sea: the two latter, however, descend to the plains, the former never do. The bear, the lynx, and the stoat are sometimes met with nearly at the limit of perpetual snow.

Some European animals are much circumscribed in their localities. The *Mouflon* is confined to Corsica and Sardinia; a species of *Weasel* and *Bat* inhabit Sardinia only; and Sicily has several bats and mice peculiar to it. There is only one species of *Monkey* in Europe, which lives on the rock of Gibraltar, and is supposed to have been introduced from Africa. All the indigenous British quadrupeds now existing, together with extinct hyæna, tiger, bear, and wolf, whose bones have been found in caverns, are also found in the same state in Germany. Ireland was probably separated by St. George's Channel from England before all the animals had migrated to the latter; so that our squirrel, mole, polecat, dormouse, and several smaller quadrupeds, never reached the sister island. Professor Owen has shown that the British horse, ass, hog, the smaller wild ox, the goat, roe, red deer, beaver, with many small rodents, are the same species with those which had coexisted with the mammoth or fossil elephant, the great N. hippopotamus, and two kinds of rhinoceros long extinct; so that a part only of the modern tertiary fauna has perished, from whence he infers that the cause of their destruction was not a violent universal catastrophe from which none could have escaped. The Bos longifrons and the gigantic Elk of the Irish bogs, now an extinct species, and also, according to the evidence of flint weapons in drift deposits, the Mammoth, hairy Rhinoceros, and other large animals, were probably coexistent with man.

The severity of the climate in Siberia renders the skins of its numerous fur bearing animals more valuable. These are *reindeer*, *elks*, *wolves*, the large *white bear* that lives among the ice on its Arctic shores, several other bears, the *lynx*, various kinds of *martens* and *cats*, the common, the blue, and the black *fox*, the *ermine*, and sable producing *polecats* and *weasels*. The fur of these last is much esteemed, and is only equalled by that of the

sea otter, which inhabits the shores on both sides of the N. Pacific.

Many species of *Gnawers* are confined to Siberia. The most remarkable of these is the ***Flying Squirrel***, or ***Jerboa***, which burrows in sandy deserts. The Altaï Mountains teem with wild animals: besides many of those already mentioned, we also find here several large ***Deer***, ***Bears***, some peculiar ***Weasels***, the ***Argali***, and the *Wild sheep*. The ***Ibex*** of the Alps is found in the Sayansk part of the chain; the *Glutton* and ***Musk Deer*** in the Baikal; and in Dauria the ***Red Deer*** and the ***Saiga Antelope***. The ***Bengal Tiger*** and the ***Felis Irbis***, a species of panther, wander from the Celestial Mountains to the Altaï and into S. Siberia: the *Tiger* is met with even as far N. as the banks of the Ob, and also in China, but in these N. regions it differs considerably, although not specifically, from that of Bengal; thus it can exist in an annual temperature varying from 81° Fahr. to the freezing point. The animals of Japan have a strong analogy with those of Europe: many are identical, or slightly varied, as the badger, otter, mole, common fox, marten, and squirrel. On the other hand, a large species of bear in the island of Yesso resembles the grizzly bear in the Rocky Mountains of North America. A chamois in other parts of Japan is nearly allied to the *Antilope Montana* of the same mountains; and other animals natives of Japan are the same with those in Sumatra; so that its fauna is a combination of those of very distant regions.

§ 3. **Asiatic Quadrupeds.**—Asia has a greater number and a greater variety of wild animals than any country except America, and also a larger proportion of those that are domesticated. Though civilised from the earliest ages, the destruction of the animal creation has not been so great as in Europe, owing to the inaccessible height of the mountains, the extent of the plains and deserts, and, not least, to the impenetrable forests and jungles, which afford them a safe retreat.

Asia Minor is a district of transition from the fauna of Europe to that of Asia. There the *Chamois*, *Ibex*, *Brown Bear*, *Wolf*, *Ox*, *Hare*, and others, are mingled with the *Hyæna*, *Angora Goat*, which bears a valuable fleece, the *Argali* or wild sheep, the *White Squirrel*; and even the *Bengal Royal Tiger* is sometimes seen on Mount Ararat, and is not uncommon in Adarbaijan and the mountains of Persia.

Arabia is inhabited by the *Hyæna*, *Panther*, *Jackal*, and *Wolf*. *Antelopes* and *Monkeys* are found in Yeman. Most of these are also indigenous in Persia. The *Wild Ass*, or Onagra, the *Gorkhar* of N.W. India, a handsome spirited animal of great speed, and so shy that it is scarcely possible to approach it, wanders in herds

over the plains and table-lands of Central Asia, extending its migrations as far as the plains of Baluchistan and Sindh, to the Indian desert, and to the Runn of Kutch—'the wilderness and the barren lands are his dwelling.' There is a distinct species (the *Kiang*) that lives in the most elevated regions of Tartary and Tibet; it has been seen on the shores of the sacred lakes of Mansarowar and Rakas Tal, at a height of more than 15,250 ft. above the sea, and on one occasion as high as 18,600.

A few animals are peculiar to the high cold plains of the table-land of E. Asia: the *Dziggetai*, a very fleet animal, is peculiar to these Tartarian steppes. Two species of *Antelopes* inhabit the plains of Tibet, congregating in immense herds, with sentinels so vigilant that it is scarcely possible to approach them.

The *Dzeran*, or yellow goat, which is both swift and shy, and the handsome Tartar Ox, are natives of these wilds; also the *Shawl-wool Goat* and the *Manul*, from which the Angora cat, so much admired in Persia and Europe, is descended. Many of the animals that live at such heights cannot exist in less elevated and warmer regions, exhibiting an instance of the limited distribution of species. Goats and sheep endure best the rarefied air and great cold of high lands; the *Cashmere* goat and *Argali* sheep browse on the plains of Tibet at elevations of from 10,000 to 13,000 ft.; the *Rass*, a sheep with spiral horns, lives on the table-lands of Pamir, which are 15,000 ft. above the sea; and also the *Kutch-gar*, a species of sheep which is about the height of a year-old colt, with fine curling horns: they congregate in flocks of many hundreds, and are hunted by the nomade tribes of Kirghis.

The *Ruminating Animals* of Asia are more numerous than those of any other part of the world: 64 species are native, and 46 of these exist there only. There are several species of *Wild Oxen*; one in the Birmese empire, and on the mountains of N.E. India, with spiral twisted horns. The *Buffalo* is a native of China, India, Borneo, and the Sunda Islands; it is a large animal, formidable in a wild state, but domesticated throughout the East. It was introduced into Italy in the sixth century, and large herds now graze in the low marshy plains near the sea.

Various kinds of oxen have been domesticated in India from time immemorial; the *Zebu* or *India Ox*, with a hump on the shoulders, has been venerated by the Brahmins for ages. The *Yak*, a beautiful animal, which is chiefly employed as a beast of burthen by the Tibetans, has long been domesticated, and can live on the passes of the Himalayas as high as 19,300 ft. Its white silky tail, used in the East to drive away flies, has been adopted as the Turkish standard; and the common Indian ox differs from all others in the great speed of its course. Some other species of

cattle have been tamed, and some are still wild in India, Java, and other Asiatic islands. The *Cashmere Goat*, which produces the shawl wool, is the most valuable of the several varieties of goats and sheep of Asia; it is kept in large herds in the great valleys on the N. and S. declivities of the Himalayas, and in the upper regions of Bhutan, where the cold climate is congenial to it.

The *Bactrian Camel*, with two humps, is strong, rough, and hairy, and is said to be found in a wild state in N.W. Tsaidam:[1] it is the camel of Central Asia, N. of the Himalayas and the Taurus Mountains, also of the Crimea and the countries round the Caucasus. The more common of Arabian species, the *Dromedary*, with one hump, is a native of Asia, though only known now in a domesticated state: it has been introduced into Africa, Italy, the Canary Islands, and even into the elevated regions of the Peru-Bolivian Andes. The best come from the province of Nejd in Arabia, which on that account is called the 'mother of camels.' The camel of Oman is remarkable for beauty and swiftness.

Ten species of *Antelopes* and 20 of deer are peculiar to Asia: 2 species of antelopes have already been mentioned as peculiar to the table-lands, the others are distributed over the islands of the Asiatic archipelago. The *Musk Deer* (*Moschus moschiferus*) inhabits the mountainous countries of Central and S.E. Asia, between China and Tartary, the regions round Lake Baikal, the Altaï Mountains, Nepal, Bhutan, Tibet, and the adjacent country of China.

Asia possesses about 10 species of *Pachydermata* including the *Elephant, Horse, Ass*, which have been domesticated from the time of the earliest historical records. The horse is still said to exist in a wild state in the plains of Central Asia,[2] as the dromedary in Arabia, though now they are only known as domestic animals. The Arabian and Persian horses possess acknowledged excellence and beauty, and from these our best European breeds are descended; the African horse, which was introduced into Spain by the Moors, is probably of the same race.

The *Elephant* has long been a domestic animal in Asia, though it still roams wild in formidable herds through the forests and jungles at the foot of the Himalayas, in other parts of India, the Indo-Chinese peninsula, and the islands of Sumatra and Ceylon; the hunting elephant is esteemed the most noble. A one horned *Rhinoceros* is a native of continental Asia.

There are several genera of Asiatic *Carnivorous Animals*, of which the *Royal Tiger* is the most beautiful and formidable; its

---

[1] See Prejevalsky's 'Mongolia,' pp. xxvi. seqq. and vol. ii. pp. 169 seqq.

[2] Ibid, vol. ii. p. 169.

favourite habitation is in the jungles of Hindustan, though it wanders nearly to the limit of perpetual snow in the Himalayas, to the Persian and Armenian mountains, to Siberia and China. *Leopards* and *Panthers* are common, and there is a maneless variety of the *Lion* in Gujerat; the *Cheetah*, used in hunting, is the only one of the leopards capable of being tamed. The *Hyæna* is found everywhere, excepting in the Birmese empire, in which there are neither wolves, hyænas, foxes, nor jackals. There are 4 species of *Bears* in India; that of Nepal is said to furnish a valuable fur: the *Wild Boar*, *Hog*, and dogs of endless variety, abound all over the continent.

The *Edentata* have only two representatives in India, which differ from all others except the African in being covered with imbricated scales. Of these the short tailed *Pangolin*, or scaly anteater, is found throughout the Deccan, Bengal, Nepal, the S. provinces of China, and in the Island of Formosa.

The Indian Archipelago and the Indo-Chinese peninsula form a zoological sub-province, having several animals exclusively its own. The *Royal Tiger* abounds in the peninsula of Malacca, and also the black variety of the *Panther*, *Leopard*, *Wild Cats*, multitudes of *Elephants*, the *Rhinoceros* of the 3 Asiatic species, the *Malayan Tapir*, numerous species of *Deer*, the *Babiroussa Hog*, and another species of that genus. Some groups of the islands have several animals in common, either identical or with slight variations, that are altogether wanting in other islands, which, in their turn, have creatures of their own. Many species are common to the archipelago and the neighbouring parts of the continent, or even to China, Bengal, Hindustan, and Ceylon. *Flying Quadrupeds* are a distinguishing feature of this archipelago, though some do not absolutely fly, but by an extension of the skin of their sides to their legs, which serves as a parachute, are enabled to take long leaps and to support themselves in the air. *Nocturnal flying squirrels*, of several species, are common to the Malayan peninsula and the Sunda Islands, especially Java; and 3 species of flying *Lemurs* inhabit Sunda, Malacca, and the Pelew Islands. Besides these, there are the frugivorous bats, which really do fly, differing from bats in other countries by living exclusively upon vegetable food. The *Roussette*, or *Kalong*, which is used as an article of food, one of the largest known, appears in flocks of hundreds, and even thousands, in Java, Sumatra, and Banda: the *Pteropus funereus*, another of these large bats, assembles in as great numbers.

About 180 species of the ape and *Monkey Tribe* are entirely Asiatic: monkeys are found only on the coast of India, Cochin-China, and the Sunda Islands: the long armed apes or Gibbons belong to the Sunda Islands and the peninsula of Malacca. The *Simayang*, a very large ape of Sumatra, moves about in large

troops, following a leader, and makes a howling noise at sunrise and sunset that is heard miles off. Sumatra and Borneo are the peculiar abode of the *Orang-outang*, a name which in the Malay language signifies 'man of the woods;' except perhaps the Chimpanzee of Africa, it approaches nearest to man. It has never spread over the islands it inhabits, though there seems to be nothing to prevent it, but it finds all that is necessary within a limited district. The orang-outang and the long armed apes have extraordinary muscular strength; they swing from tree to tree by their arms.

The Malays have given the name of orang, or man, to the whole tribe, on account of their intelligence as well as their form.

A two horned *Rhinoceros* is peculiar to Sumatra, of a different species from the African, also the *Felis macrocelis*, and a very large *Bear*; there are only 2 species of *Squirrels* in Java, which is remarkable, as the Sunda Islands abound in them. The *Royal Tiger* of India and the *Elephant* are found in Sumatra, and the *Babiroussa Hog* in Borneo; but these two islands possess many quadrupeds in common, as a *Leopard*, the *Black Antelope*, some graceful miniature creatures of the deer kind, the *Tapir*, also found in Malacca, besides a wild bear, an inhabitant of all the marshy forests from Borneo to the Moluccas. In the larger islands *Deer* abound, some as large as the elk, probably the Hippelaphus of Aristotle.

The *Anoa*, a ruminating animal about the size of a sheep, a species of antelope, shy and savage, goes in herds in the mountains of Celebes, where many animals strangers to the Sunda Islands, begin to show themselves, as some sorts of *Phalangers*, or pouched quadrupeds. These new forms become more numerous in the Moluccas, which are inhabited by *Flying Phalangers* and other pouched animals, with hairless scaly tails. The phalangers are nocturnal, and live on trees. In New Guinea there are *Kangaroos*, the *Spotted Phalanger*, the *New Guinea Hog*, and the *Papua Dog*, said to be the wild species from which all the native dogs in Australia and Oceania, wild or tame, are descended. The E. islands of the Archipelago, in fact, belong to a zoological division quite distinct from Southern Asia, and, according to Mr. Wallace, should be classed with Australia. The line of division is a deep sea channel running nearly S.E. and N.W. through the islands, beginning with the narrow strait which separates the Islands of Bali and Lombok and running between Borneo and Celebes. Celebes is to some extent an intermediate land, possessing a representative of the Quadrumana order. In all the other E. islands, as in Australia, monkeys, pachydermata, and a host of other families, genera, and species common in the W. islands and S. Asia, are entirely unknown. It is remarkable that this classification corresponds with the depth of the seas separating the lands; Borneo, Sumatra,

and Java being connected with the Malayan Peninsula by a shallow sea, just as New Guinea and its surrounding islands are connected by a channel of small depth with Australia.

§ 4. **African Quadrupeds.**—The opposite extremes of aridity and moisture in the African continent have had great influence on the nature and distribution of its animals; and since by far the greater part consists of plains utterly barren or covered by temporary verdure, and watered by periodical streams that flow only during a few months in the year, fleet animals, fitted to live on arid plains, are far more abundant than those that require rich vegetation and much water. The latter are chiefly confined to the intertropical coasts, and especially to the large jungles and deep forests in the centre and at the northern declivity of the table-land, where several genera and many species exist that are not found elsewhere. Africa has a fauna in many respects different from that of every other part of the globe; for although about 100 of its quadrupeds are common to other countries, there are 250 species exclusively its own. Several of these animals, especially the larger kinds, are distributed over the whole table-land from the Cape of Good Hope to the islands of Abyssinia and Senegambia without the smallest variety; some are slightly modified in colour and size. *Ruminating Animals* are very numerous, though few have been domesticated: of these the *Ox of Abyssinia and Bornou* is remarkable from the extraordinary size of its horns, which are sometimes 2 ft. in circumference at the root; the *Galla Ox of Abyssinia* has horns 4 ft. long; and the *Ox from Kuruman*, in the territory of our Cape Colony, 5 ft. in length, by one and three-quarters in diameter at the base. There are many African varieties of *Buffalo*; that at the Cape of Good Hope is a large, fierce animal, wandering in herds in every part of the country, even to Abyssinia: the flesh is sometimes impregnated with the odour of musk. The African *Sheep* and *Goats*, of which there are many varieties, differ from those of other countries; the wool of all is coarse, except that of the Merino sheep, said to have been introduced from Morocco into Spain by the Moors.

No country possesses a *Ruminating Animal* similar to the *Giraffe*, or Camelopard, which ranges widely over S. Africa from the N. banks of the Gareep, or Orange River, to the Great Desert; it is also found in Dongola and in Abyssinia. It is a gentle timid animal, and has been seen, though rarely, in troops of 100. The earliest record we have of it is on the sculptured monuments of the ancient Egyptians, and it is well known that it was brought to Rome to grace the triumph of a victorious emperor.

Africa may truly be called the land of the genus *Antilope*, which is found in every part of it, where it may be said to repre-

sent the deer of Europe, Asia, and America. Different species have their peculiar localities, while others are more widely dispersed. The greater number are inhabitants of the open plains, while a few penetrate into the forests. About 70 species have been described, of which at least 26 are found N. of the colony of the Cape of Good Hope and in the adjacent countries. They are of every size, from the *Pigmy Antelope*, not larger than a hare, to the *Caama* and the *Eland*, which are as large as the ox and horse. Timidity is the universal character of the race. Most of the species are gregarious; and the number in a herd is far too great even to be guessed at. Like all animals that feed in herds, they have sentinels; and they are the easy prey of so many carnivorous animals that their safety requires this precaution. At the head of their enemies is the lion, who lurks among the tall reeds at the fountains, to seize them when they come to drink. The antelopes for the most part are graceful in their motions, especially the *Springbok*, which travels in compact troops; and in their march there is constantly one which gathers its slender limbs together, and bounds into the air.

Africa has only 2 species of *Deer*, both inhabiting the chain of the Atlas: one is the common fallow deer of Europe.

There are 3 species of the *Horse* peculiar to S. Africa; of these the *Zebra*, the more sober coloured *Quagga*, and *Burchell's Quagga*, beautifully striped, wander in troops over the plains, often in company with *Ostriches*. An alliance between creatures differing in nature and habits is not easily accounted for. The two horned rhinoceros of Africa is different from that of Asia; there are certainly three, and probably five species of these huge animals peculiar to the table-land. Dr. Smith saw 150 in one day near 24° S. lat. The *Hippopotamus* is exclusively African: multitudes inhabit the lakes and rivers in the tropical and S. parts of the continent; those that inhabit the Nile and Senegal, if they do not belong to a different species, form a very marked variety. The *Elephant* differs very considerably from that of Asia, and is so numerous that 200 have been seen in a herd near Lake Chad: and according to the accounts of recent explorers they seem to be equally numerous in other parts of the interior of the continent. They are not domesticated in Africa, and are hunted by the natives for their tusks. The *Phacochœrus*, or Wart-hog, lives beyond the limits of Cape Colony; and the *Bosch Vark* (*Sus larvatus*), on its E. coasts, as well as a species of *Hyrax*, are among the peculiar Pachydermata of this continent. The *Monkey tribe* is found in all the hot parts of Africa: peculiar genera are allotted to particular districts. Except a few in Asia, the group of the *Guenon Monkeys* is found in no other part of the world than

about the Cape of Good Hope, and on or near the coasts of Loanda and Guinea. The species are numerous, and vary much in size and colours; the *Cynocephalus*, or dog headed baboon, with a face like that of a dog, is large, powerful, and dangerous. A species of these baboons inhabits Guinea, others the S. parts of the table-land, and one is met with everywhere from Senaar to Caffraria. A remarkable long haired species of baboon, the *Hamadryas*, is found in the mountains of Abyssinia, 800 ft. above the sea; the *Mandrills*, which belong to the same genus, come from the coasts of Guinea. The *Magot*, or Barbary Ape, is common over N. Africa. The African long haired tailless apes, which form the genus *Colobus*, are met with in the tropical districts on the W. coast; the *C. Polycomos*, or king of the monkeys, so called by the natives from its beautiful fur and singular head of bushy hair, is met with in the forests about Sierra Leone. The *Chimpanzee*, which so nearly approaches the human form, inhabits the forests of W. Africa from Cape Negro to the Gambia. Living in troops, like most apes and monkeys, which are eminently gregarious, it is very intelligent and easily tamed. A new genus, the *Gorilla*, allied to the Chimpanzee, surpassing in size the Orang-outang, was first accurately described by Professor Owen: its habitat is restricted to the equatorial coast forests around the Gaboon and Fernand Vaz Rivers. Other species or varieties of the Chimpanzee were added by the indefatigable explorer M. du Chaillu.[1]

Africa possesses the *Cat Tribe* in great variety and beauty; *Lions, Leopards*, and *Panthers* are numerous throughout the continent; *Servals* and *Viverrine Cats* inhabit the torrid districts; and the lion of the Atlas has ever been considered the most formidable of carnivorous animals. In no country are *Foxes* so abundant. Various species inhabit Nubia, Abyssinia; and about the Cape of Good Hope we find the lion, leopard, and the serval. A long eared fox of nocturnal habits, the Fennec of Bruce, found from the Cape of Good Hope to Kordofan, is peculiar to Africa. There are also various species of *Dogs*, the *Hyæna*, and the *Jackal*. The hyænas hunt in packs, attack the lion and panther, and end by destroying them.

Two genera of *Edentata* are African—the long tailed *Manis* of several species, and the *Aard-vark*, or earth-hog; the first is covered with horny scales, the latter with coarse long hair; they burrow in the ground and feed on ants. Great flocks of a large migratory frugivorous bat frequent the Slave Coast.

Multitudes of *Antelopes* of various species, *Lions, Leopards, Panthers, Hyænas, Jackals*, and some other *Carnivora*, live in the oases

[1] 'Adventures in Equatorial Africa,' 1861.

of the great N. deserts; *Jerboas,* and endless species of *Rats, Mice*, and other small rodents, burrow in the ground. The dryness of the climate and soil keeps the coats of the animals clean and glossy; and it has been observed that tawny and grey tints are the prevailing colours in the fauna of the N. African deserts, not only in the birds and beasts, but in reptiles and insects. In consequence of the continuous desert extending from N. Africa through Arabia to Persia and India, many identical species of quadrupeds exist in those countries.

The fauna of the great Island of Madagascar is in some small degree analogous to that of India, though, as far as it is known, it seems to form a distinct centre of animal life. It has no ruminating animals, Pachyderms or large Felidæ; and the *Monkey Tribe* is represented by the *Lemurs,* the *Galagos,* and *Indris,* animals characteristic of this insular fauna. A frugivorous *Bat,* the size of a common fowl, forms an article of food; and one of the most extraordinary of the existing mammals, the *Aye-aye* (Chiromys), an exceedingly specialised form of the Lemuroid type, is confined to this island.

§ 5. **American Quadrupeds.**—America is probably the richest zoological province in the world, possessing nearly 600 species of mammalia, of which 480 are peculiar to it; yet no country has contributed so little to the stock of domestic animals. With the exception of the llama and alpaca, the turkey, and perhaps some varieties of dogs, America has furnished no quadruped or bird serviceable to man, while it has received from Europe all its domestic animals and its present civilised inhabitants.

Arctic America possesses most of the valuable *Fur bearing Animals* that are found in Siberia; and they were very plentiful till the unsparing destruction of them has driven those yet remaining to the high latitudes, where the hunters that follow them are exposed to great hardships. Nearly 2,000,000 of skins are brought annually to England, most of which are taken in the forest regions. The Barren Grounds are inhabited by the *Arctic Fox*, the *Polar Hare,* the *Brown* and the *White Bear*, a formidable animal which generally lives on the ice itself. The *Reindeer* feeds on the lichens and mosses of these barren grounds, and wanders to the shores of the Polar Ocean: its S. limit in Europe is the Baltic Sea, in America the latitude of Quebec. Some of the fur bearing quadrupeds of these deserts never pass 65° N. lat.; the greater number live in the N. forests, as the *Black Bear*, *Racoon*, *Badger*, the *Ermine* and 4 or 5 other members of the *Weasel Tribe*, the *Red Fox*, the *Polar* and *Brown Lynxes*, the *Beaver*, the *Musquash* or musk rat, of which half a million are killed annually for their fur, and the *Elk* or moose deer, whose N. range ends where the aspen and willows, its principal

food, cease to grow. The *Grizzly Bear*, the largest and most ferocious of its kind, inhabits the range of the Rocky Mountains as far S. as Mexico, as well as the W. savannahs. The *Prairie Wolf*, the *Grey Fox*, the *Virginian Hare*, live in the prairies; the *Wapiti*, the largest of the deer tribe after the elk, inhabits those on both sides of the Rocky Mountains; and the *Prongbuck*, an antelope fleeter than the horse, remarkable for its bifurcated horns, roams throughout the W. part of the continent, and migrates in winter to California and Mexico. The *Musk Ox* and *Bison* are peculiar to North America. The musk ox extends its migrations N. to Parry Islands and Banks Land in the Arctic regions, yet it never has been seen in Greenland or on the N.W. side of the continent. The bison is met with as far S. as the Arkansas, and roams, in herds of thousands, over the prairies of the Mississippi and on both sides of the Rocky Mountains. It seldom wanders farther than 60° N. lat., the southern limit of the musk ox. A species of *Marmot* known by the name of the Prairie Dog is everywhere to be met with in the great plains from which it derives its name.

There are at least 8 varieties of *American Dogs*, several of which are natives of high N. latitudes. The *Lagopus*, or Isatis of Spitzbergen and Greenland, is found over the Arctic regions of America and Asia, and in the Kurile Islands. Dogs are employed to draw sledges in Newfoundland and Canada; and the Esquimaux travel drawn by dogs as the Lapps and the Finns do by reindeer. These dogs are strong and docile; they were mute till they learned to bark from European dogs in our discovery ships.

There are 13 species of *Ruminating Animals* in North America, including the bison, the musk ox of the Arctic regions, the big horned sheep, and the goat of the Rocky Mountains. The horse, now roaming wild in innumerable herds over the plains of South America, was unknown there till the conquest by the Spaniards. The quadrupeds of the temperate zone are distributed in distinct groups: those of the State of New York, consisting of about 40 species, are different from those of the Arctic regions, and also from those of South Carolina and Georgia; while in Texas another assemblage of species prevails.

There are about 130 species of *Rodents*, or gnawing animals, in North America—*Rats*, *Mice*, *Squirrels*, *Beavers*, &c.—some of which, especially in the N., appear to be identical with those in the high latitudes of Europe and Asia. The genera of very different latitudes are often representatives, but never identical. Squirrels abound in North America; the grey squirrel is very abundant.

About 30 species of the genus *Opossum* are enumerated as existing in this continent. Of these the Virginian opossum in-

habits the whole extent of America from the Canadian lakes to Paraguay, and also the West India Islands, where it is called the Manicou; and two other species of the tribe live in Mexico. There is a *Porcupine* in the United States and Canadian forests which climbs trees; and others of the same genus are found in South America.

The high land of Mexico forms a very decided line of demarcation between the fauna of North and South America; yet some North American animals are met with beyond it, particularly 2 *Bears* and an *Otter*, which inhabit the continent from the Icy Ocean to beyond Brazil. On the other hand, the *Puma*, *Jaguar*, *Opossum*, *Kinkajou*, and *Peccari*, have crossed this barrier, from South America to California and the United States.

In the varied and extensive regions of South America there are several centres of a peculiar mammalian fauna, according as the country is mountainous or level, covered with forest or grass, fertile or desert, but the animals are inferior in size to those of the Old World. The South American quadrupeds are on a smaller scale, more feeble and more gentle; many of them, as the toothless group including the Sloths, are of anomalous and less perfect organisation than the rest of the mammalian creation.

The *Monkey Tribe* exist in myriads in the forests of tropical America and Brazil; but they are met with in small numbers to the N. of the Isthmus of Darien, and not farther S. than the Rio de la Plata. They differ widely from those in the Old World, being farther removed from the human form; but they are more gentle and lively. Notwithstanding their agility, they are often victims to birds and beasts of prey.

There are two principal groups of American monkeys—the *Sapajous*, with prehensile tails, by which they suspend themselves and swing from bough to bough; some of these inhabitants of the woods are very noisy, especially the Araguato, a large ape whose howling is heard a mile off. The Howlers are generally very large, and have a wider range than any others of the genus; one species, the *Mycestes rufimanus*, or Beelzebub, ascends the Andes to the height of 11,000 ft. The *Cebus*, or Weepers, which are frequently brought to Europe, belong also to this family; the genus has a greater number of species than any other monkey of the New World, but a very narrow location to each; they are most abundant in Guiana.

Squirrel-monkeys and *Marmosets* form the second group of American monkeys. They inhabit the banks of the Orinoco, and the forests of Brazil. The marmosets are pretty little animals, easily tamed, especially the Midas leonina, not more than 7 or 8 inches long.

The forests are also inhabited by *Opossums*, a genus of the marsupial order, which carry their young in pouches; they are somewhat analogous to the race of animals that form the distinguishing feature of the Australian fauna, but of entirely distinct genera and species. Some of these animals are no larger than a rat, and they mostly live on trees. One is aquatic, the *Chironectes*, resembling a small otter, and appears to be only found in the river Yapock in French Guiana. A species in Surinam carries its young upon its back. All the Opossums and the Chironectes have thumbs on their hind feet, opposable to the toes, so that they can grasp; they are, moreover, distinguished from the Australian marsupials by a long prehensile tail, and by greater agility.

Five genera and about 30 species of the *Edentata* are characteristic of this continent, and confined to South America; they consist of the several species of *Sloths*; several *Armadilloes*, the *Chlamyphorus*; and 4 or 5 *Myrmecophagæ* or Ant-eaters. The animals of these genera have very different habits: the sloths, as their name implies, are the most sluggish of animals; they inhabit the forests from the S. limit of Mexico to Rio de Janeiro, and to the latitude of the region of Palms and Scitamineæ, as high as 3000 ft. on the declivities of the Andes. The Armadillo, in its coat of mail, is in perpetual motion, and can outrun a man in speed. They live on the plains of South America, as far S. as Paraguay and the Pampas of Buenos Ayres. The one banded armadillo rolls itself up like a ball; the nine banded one is eaten by the natives; the giant armadillo, 3 ft. long, inhabits the forests. Most of these species are nocturnal, and burrow in the earth in the Pampas. The *Chlamyphorus* is also a burrowing animal, peculiar to the province of Mendoza on the E. slope of the Chilian Andes; they have the faculty of sitting upright, for which the hinder part of their scaly armour is admirably adapted. The *Great* or *Maned Ant-eater* (*M. Jubata*), larger than a Newfoundland dog in the body, but with shorter legs, defends itself against the jaguar with its powerful claws; it inhabits the swampy savannahs and damp forests from Venezuela to Paraguay, and from the Atlantic to the foot of the Andes; its flesh, like that of some other American animals, has a strong smell of musk. The *Little Ant-eater* (*M. Tamandua*) has a prehensile tail, and lives on trees in the tropical forests, feeding on the larvæ of bees and wasps, honey, and ants. The *Cat Tribe* in South America are beautiful in their colours and powerful in strength: the *Puma*, called the Lion of America, is found in great numbers both in the mountains and the plains. So different are its habits in different places, that in Chile it is timid and flies from a dog; in Peru it is bold, though it rarely attacks the human race. The *Jaguar*, which inhabits the deep tropical forests,

is very abundant, and so ferocious that it will sometimes spring upon Indians in a canoe; it is one of the few South American animals that extend beyond the Isthmus of Panama, being found in California and in the State of Mississippi; it has been seen even as far N. as Canada; offering a remarkable analogy, in its extensive wanderings, with the Royal Tiger of the Old World, which, as we have already seen, is often found amidst the mountains and steppes of Central Asia and Siberia.

The only *Ruminating Animals* except the deer that existed in South America prior to the conquest were the 4 species of the genus *Auchenia*—the *Llama*, the *Alpaca*, the *Vicuña*, and the *Guanaco*: the first 3 are exclusively confined to the colder and more elevated regions of the Peruvian Andes; the last has a wider geographical range, extending to the plains of Patagonia, and even to the southernmost extremity of the continent. The Llama inhabits the high valleys of the Peru-Bolivian Andes, its favourite region being in the valley of the Lake of Titicaca: it was the only beast of burden possessed by the aborigines; hence we find it domesticated wherever the Incas carried their conquests and civilisation, from the equator to beyond the S. tropic. It is still extensively employed by the Indian as a beast of burden, and its wool, though coarse, is used by the natives for their clothing. Like all domestic animals, it varies in colour: its flesh is dark and disagreeable to the taste.

The *Alpaca*, or Paco, a gentle and handsome animal, although more closely allied to the llama than any of its congeners, appears to be a distinct species: it lives in still more elevated sites than the llama, its favourite haunts being on the streams descending from the snowy peaks: it is only found in a domestic state; it is reared for its wool, which is extremely fine, silky, and long, and which now bears a high price, from its introduction into some of our finest woollen tissues.[1] The *Vicuña* is only found in the wild state in the plains on the Andes, as high as 15,000 ft.; the wool is much prized for its fineness. This animal has a shrill whistle; it is easily tamed. The *Guanaco*, by some naturalists considered erroneously as the parent stock of the llama and alpaca, is also only found in the wild state: it extends to 12° S. lat., is very abundant and in large flocks on the Bolivian and Chilian Andes, and has been seen as far S. as the Strait of Magellan. All these animals feed principally on a species of coarse, wiry grass called *ichu*.

Several species of *Deer* are found in the tropical regions of South

[1] The alpaca has been introduced into the colony of New South Wales with great success.

America, and a remarkable one, the *Cervus Andium*, with fragile hair like that of the roebuck of Europe, as high as 11,000 ft. in the Andes.

Among the *Rodentia*, the *Agoutis* represent our hares in the plains of Patagonia, in Paraguay, &c., and extend as far N. as Guiana. The tribe of the *Cavias*, or guinea pigs, are found in Brazil, and some species in the great table-lands of the Peru-Bolivian Andes; the *Echimys* or prickly rat, is an inhabitant of the banks of the Rio de la Plata and Paraguay; the *Vizcacha* of the Pampas, a burrowing animal, inhabits the great plains of Buenos Ayres; an animal bearing the same name, but of a very different species, is frequent in the rocky regions of the Andes, as high as 15,000 ft. above the sea; and the beautiful *Chinchilla*, nearly allied to the latter, whose fur is so highly esteemed, inhabits the same regions, at the same great elevations, in the Andes of South Peru, Bolivia, and Chile: the best fur of the chinchilla is collected in the Bolivian province of Potosi, and in the Chilian province of Copiapo. The largest of all the rodentia, the *Capybara* (Myopotamus), inhabits the banks of the great rivers of tropical America, where its habits resemble, according to some travellers, those of the hippopotamus. The *Paca*, the next in size, is less aquatic in its habits, and lives in the dense forests of Brazil and Paraguay.

It is very remarkable that, in a country which has the most luxuriant vegetation, there should not be one native species of hollow horned ruminants, as the ox, sheep, goat, or antelope; and it is still more extraordinary that the existing animals of South America, which are so nearly allied to the extinct inhabitants of the same soil, should be so inferior in size not only to them, but even to the living quadrupeds of South Africa, which is comparatively a desert as regards its vegetation. The quantity of vegetation in Brazil at any one time exceeds the quantity of an equal area in the interior of South Africa very considerably, yet Dr. Darwin has computed that the weight of 10 of the largest South African quadrupeds is 24 times greater than that of the same number of quadrupeds in South America; for in South America there is no animal of the size of a cow, so that there is no relation between the bulk of the species and the vegetation of the countries they inhabit.

The largest animals indigenous in the West India Islands are the *Agouti*, the *Racoon*, the *Houtias*, a native of the forests of Cuba; the carnivorous *Didelphi* and the *Kinkajou* are common to them and to the continent; the Kinkajou is a solitary instance of a carnivorous animal with a prehensile tail.

§ 6. **Australian Quadrupeds.**—Australia is not farther separated from the rest of the world by geographical position than

by its fauna. Its animals are creatures apart, of an entirely separate type; they are few as regards species, and still fewer as to individuals, if the vast extent of country be taken into consideration; and there has not been one large animal discovered in it. There are about 160 species of mammalia in Australia, and there is not a single example of the ruminating or pachydermatous animals, so useful to man, among them. There are no native horses, oxen, or sheep; yet all these thrive and multiply on the grassy steppes of the country, which seem to be so well suited to them. There are none of the monkey tribe; indeed, they could not exist in a country where there is scarcely any fruit.

Of the species of indigenous quadrupeds, nearly all are confined to this continent, and by far the greater number are *Marsupial Animals,* distinguished from all others by their young being as it were prematurely born and nourished in the pouch till they are able to fare for themselves.[1] Though all the members of this numerous family agree in this circumstance, they are dissimilar in appearance, internal structure, in their teeth and feet, consequently in their habits; 2 genera live on vegetable food, one group are gnawers, and another entirely deprived of teeth. The *Kangaroo* and the *Kangaroo Rat* walk on their hind legs, and advance by bounds, springing from their strong tails; the kangaroo rat holds its food in its paws like the squirrel; the *Phalangers* live on trees, and swing by their bushy tails—some burrow in the sand; the *Flying Opossum,* or Petaurus, peculiarly an Australian animal, lives at the foot of the Blue Mountains, on the leaves of the gum tree; by expanding the skin of its sides as a parachute, it supports itself in the air in its leaps from bough to bough. Several of the genera are nocturnal, a characteristic of many Australian animals.

The *Pouched Tribe* vary in size from that of a large dog to a mouse; the kangaroos, which are the largest, are easily domesticated, and are used for food by the natives. Some go in large herds in the mountains, others live in the plains; however, they have become scarce near the British colonies, and, with all other native animals, are likely to be soon extirpated. In Tasmania they are less persecuted; several species exist there. The kangaroos are more widely dispersed than any of the marsupial animals of Australasia. They exist not only in Australia and Tasmania, but also in New Guinea. The *Banded Kangaroo,* the handsomest of his tribe, is found only in the islands in Shark Bay, on the W. coast

---

[1] There are 5 tribes, 15 genera, and more than 102 species of living marsupial animals, amounting to about one twelfth of all the mammalia. The Opossum and Chironectes are American; the four other families are inhabitants of Australia and the Indian Archipelago.

of New South Wales. The *Wombat* is peculiar to Australia, the islands in Bass Strait, and Tasmania; to which the 2 largest carnivorous marsupials peculiarly belong, called by the natives the *Zebra Wolf* (*Thylacinus*) and the '*native Devil*' (*Garcophilus*); both are nocturnal, predatory, and fierce. A *Wild Dog* living in the woods, whose habits are ferocious, is, with the Zebra wolf, the largest carnivorous animal in Australia.

The *Gnawing Animals* are aquatic and very peculiar; but the *Monotremata* of Australia are quite anomalous, and peculiar to the country; of these there are two genera, the *Ornithorhynchus*, or duck billed mole, and the *Echidna*: they are the links that connect the Edentata with the pouched tribe, and mammalia with oviparous animals. The Ornithorhynchus is about 14 inches long, and covered with thick brown fur; its skull is similar to that of a quadruped, ending in a bill like that of a duck: it has short furry legs with half webbed feet, and the hind feet are armed with claws and a sharp spur, the wounds from which are dangerous. It inhabits burrows on the banks of rivers, which have two entrances, one above, the other below, the level of the water, which it seldom leaves, feeding on insects and seeds in the mud.

The *Echidna* is similar in its general structure to the ornithorhynchus, but entirely different in external appearance, being covered with spines like the porcupine; it is also a burrowing animal, sleeps during winter, and lives on ants in summer.

A singular analogy exists between Australia and South America in this respect, that the living animals of the two countries are of the same forms and types as the extinct races of their inhabitants, many of which are gigantic representatives of the now comparatively diminutive existing animals; while in the Old Continent the difference between the existing and extinct forms of beings is decided. Australia and South America seem still to retain some of those conditions that were peculiar to the most ancient geological eras. Thus each tribe of the innumerable families that inhabit the earth, the air, and the waters, has a limited sphere. How wonderful the quantity of life that now is, and the myriads of beings that have appeared and vanished! Dust has returned to dust through a long succession of ages, and has been continually remoulded into new forms of existence—not an atom has been annihilated; the fate of the vital spark that has animated it, with a vividness sometimes approaching to reason, is one of the deep mysteries of Providence.

CHAPTER XXXVI.

DISTRIBUTION, CONDITION, AND PROSPECTS OF THE HUMAN RACE.

§ 1. **Number, Diversity, and Classification of the Human Race.**—The total population of the earth amounts to 1,423,917,000, embracing peoples in all stages of civilisation, from a high state of moral and intellectual culture, to savages but little above the animals that contend with them for the dominion of the deserts and forests through which they roam. This vast multitude is divided into nations and tribes, differing in external appearance, character, language, and religion. The manner in which they are distributed, the affinities of structure and language by which they are connected, and the effect that climate, food, and customs may have had in modifying their external forms or their moral and mental powers, are subjects of much more difficulty than the geographical dispersion of the lower classes of animals, inasmuch as the immortal spirit is the chief agent in all that concerns the human race.

The human family consists of 6 great groups,[1] marked by distinctive characters. Many nations and sub-varieties are included in each; distinguished from one another by difference of language, manners, and mental qualities, yet bearing such a resemblance in general physiognomy and appearance as to justify a classification apparently anomalous.

The *Caucasian group* of nations, which includes the handsomest and most intellectual portion of mankind, inhabit all Europe, except Lapland, Finland, and Hungary; they occupy N. Africa, as far as 20° N. lat., Arabia, Asia Minor, Persia, the Himalayas to the Brahmaputra, all India between these mountains and the ocean, and, by recent migration, the various States of America. These nations are remarkable for a beautifully shaped head, regu-

---

[1] Professor Huxley distinguishes four principal types of mankind, viz.

1. *The Australioid*, of which the best representatives are the natives of Australia and South India.

2. *The Negroid*, which is represented by the African Negro.

3. *The Mongoloid*, which prevails over the vast area that lies between Siam and Lapland.

4. *The Xanthochroic*, or fair white, which is chiefly represented by the inhabitants of North Europe.

To these the Professor adds a fifth variety which he calls *Melanochroic*, or dark white, and which are well represented by the peoples of South Europe.—*Journal of Ethnological Society*, vol. ii. p. 404, 1870.

lar features, fine hair, and symmetrical form. The Greeks, Georgians, and Circassians are models of perfection in form, especially the last, which are assumed as the type of the Caucasian variety; of which it is evident that colour is not a characteristic, since they are of all shades, from the fair and florid to the clear dark brown and almost black. This family of nations has always been and still is the most civilised portion of the human race. The inhabitants of Hindustan, the Egyptians, Arabians, Greeks, and Romans, were in ancient times what European nations are now. The cause of this remarkable development of mental power is no doubt natural disposition, for the difference in the capabilities of nations seems to be as great as that of individuals. The origin of spontaneous civilisation and superiority may generally be traced to the talent of some master spirit gaining an ascendency over his countrymen. Natural causes have also combined with mental; mildness of climate, fertility of soil; rivers and inland seas, by affording facility of intercourse, and favouring enterprise and commerce, the double river systems in Asia having brought distant nations together, and softened those hostile antipathies which separate people, multiply languages, and reduce all to barbarism. The genius of this family of nations led them to profit by these natural advantages; whereas the American Indians are at this day wandering as barbarous hordes in one of the finest countries in the world. An original similarity or even identity of many spoken languages may be adverted to as having facilitated communication and mental improvement among the Caucasian variety in very ancient times.

The *Mongol-Tartar* races form the second group of nations. They occupy all Asia N. of the Persian table-land and of the Himalayas; nearly the whole of E. Asia from the Brahmaputra to Behring Strait, together with the Arctic regions of America N. of Labrador. This family includes the Turkomans, Mongol and Tartar tribes, the Chinese, Indo-Chinese, the Esquimaux, and the Hungarians, now located in the very heart of Europe. These nations are distinguished by broad skulls and high cheek bones, small black eyes obliquely set, long black hair, and a yellow or sallow olive complexion; some are good looking, and many are well made. A portion of this family is capable of high culture, especially the Chinese, the most civilised people of E. Asia, although they never have attained the excellence of the Caucasian group, probably from their exclusive social system, which has separated them from the rest of mankind, and kept them stationary for ages; the peculiarity and difficulty of their language have also tended to insulate them. The Kalmuks, who lead a pastoral and wandering life on the steppes of Central Asia, and the Esquimaux,

have wider domains than any other of this group. The Kalmuks are rather a handsome people, and, like all who lead a savage life, have acute senses of seeing and hearing. The inhabitants of Finland and Lapland are nearly allied to the Esquimaux, who are spread over all the high latitudes of both continents—a diminutive race, equally ugly in face and form.

The third, or *Malayan, group* occupy the Malayan Peninsula, and the W. portion of the Indian Archipelago, together with the Philippines and Formosa; and a sub-variety or section of the race is spread over E. and Central Polynesia, from the Sandwich group to New Zealand; this variety in physical structure and temperament seems a mixture of Papuan and Malay. The Japanese are also supposed to be an offshoot of the Malayan stock, who have migrated in prehistoric times from the Indian Archipelago to their present homes. The ruling race of Madagascar also belongs to the Malay stock. The Malayans are of brown complexion of skin, with long coarse black hair, flat faces, and obliquely set eyes. Endowed with great activity and ingenuity, they are mild and gentle, and far advanced in the arts of social life, in some places; in others ferocious and vindictive, daring and predatory; from their maritime position and skill, they are a migratory race. Several branches of this group of nations had a very early indigenous civilisation, with an original literature written in peculiar characters of their own.

The fourth great section of the human race has been sometimes classed with the Malayan; this includes the *Papuans*, or inhabitants of New Guinea and neighbouring islands as far to the E. as the Fiji or Viti group, and the Australians. They differ from the Malays by their darker skin, the crisp and bushy nature of their hair, and their more aggressive, demonstrative, and lively dispositions. Many of the tribes of Central and S. Australia and the Tasmanians, who are now nearly extinct, are amongst the most degraded of mankind, and they offer many points of difference from the Papuans. Remnants of a dark skinned and curly headed race allied to the present are found in the Negritos of the Philippines, the Semangs of Malacca, and in the Andaman Islanders. It is also probable that several of the hill tribes in the provinces E. of the Bay of Bengal, and in S. India, are so many isolated remnants of this once widely spread section of the human species.

The fifth group of nations, the *Ethiopian*, are widely dispersed: they occupy all Africa S. of the Great Desert, and a large portion of the Island of Madagascar. The distinguishing characters are, a black skin, with woolly or frizzled hair,[1] thick lips, projecting jaws,

[1] Wool is peculiar to quadrupeds; the hair of the negro only resembles

high cheek bones, and large prominent eyes. A great variety, however, exists in this jetty race: some are handsome both in features and figure, especially in Ethiopia; and even in W. Africa, where the Negroes live, there are tribes in which the distinctive characters are less exaggerated. This great family has not yet attained a high place in civilisation, though by no means incapable of cultivation; part of Ethiopia appears to have made considerable progress in very ancient times. But the formidable deserts, so extensive in some parts of the continent, and the insalubrious climate in others, have cut off intercourse with civilised nations; and the infamous traffic in slaves, to the disgrace of Christianity, has rendered the inhabitants of tropical Africa more barbarous than they were before: while, on the contrary, the Foulahs and other tribes, who were converts to Mohammedanism 400 years ago, possess now large commercial towns, cultivated grounds, and schools.

The sixth, or *American group*, who occupy the whole of the new continent from 62° N. lat. to the Strait of Magellan, are almost all of a reddish brown or copper colour, with long black hair, black eyes, aquiline nose, and often of handsome slender forms. In North America they live by hunting, are averse to agriculture, slow in acquiring knowledge, but extremely acute, brave, and fond of war, and, though revengeful, are capable of generosity and gratitude. Some tribes in Upper Canada are becoming civilised, and show a disposition to cultivate the earth when furnished with the necessary implements. In South America many are half civilised, but a greater number are still in a state of complete barbarism. In a family so widely scattered great diversity of character prevails, yet throughout the whole there is a similarity of manners and habits which has resisted all the effects of time and climate.

Each of these 6 principal varieties of the human race consists of numerous nations and sections, offering a large amount of difference amongst themselves; and the difference not only affects the bodily structure and features, but also mental characteristics, language, and deeply rooted habits. It is sufficient to point out the obvious differences in these respects between the Celtic and Teutonic nations of Europe, and between the mild, industrious, town building red men of northern Mexico and the wild Indians of the plains, the peculiarities of whose temperament are so ineradicable that they become extinct before civilisation acquires any influence

---

it. Both hair and wool consist of a transparent tube or sheath containing a white or coloured pith, but the sheath of hair is smooth, whilst that of wool is notched, which gives it the felting property.

over them. No less striking is the difference between the colossal[1] and muscular Patagonian and the dwarfed ill shaped Fuegian, his near neighbour; and yet it is incontestable that all these belong to the same race of American red men. In Africa equally remarkable is the difference between the degraded Bushman and Hottentot and the active, warlike Kaffir, or the Mohammedan Negroes of the W. Soudan. It is probable, however, that the intermixture of two primary varieties has had much to do with the production of some of these varieties. No doubt, people of the Semitic section of the Caucasian variety have from time immemorial intermingled, in N. and E. Africa, and in the Valley of the Nile, with the N. nations of the Negro type. Some Egyptologists have suggested that the ancient Egyptians were a mixed race formed of the union of Semitic nations with Ethiopians. The world-old custom of domestic slavery has also had much to do with the mixture of races; the conquerors interbreeding with their captives. This must have prevailed extensively in S.W. Asia, and it has also probably caused an interblending of the Mongol race with various nations of the Caucasian race in the plains of Turkestan, from the borders of the Caspian to the Desert of Gobi. From these various considerations, it is not surprising that it is difficult to fix definite boundaries to the chief varieties of the human race, or to apply characters which shall be peculiar and common to all the subdivisions of one and the same variety.

§ 2. **Language, its development, varieties, affinities, &c.** —Professor Adelung has estimated that the known languages and dialects spoken by the human race amount to between 3,000 and 4,000, but few are independent; some are proved to be varieties of one stock by being connected by words having the same meaning, and by grammatical structure; indeed, the permanency of language is so great that neither ages of conquest nor mixing with other nations have obliterated the native idiom of a people. The French, Spanish, and German retain traces of the common language spoken before the Roman conquest, and the Celtic tongue still exists in the British Islands.

By a comparison of their dialects, nations far apart, and differing in every other respect, are discovered to have sprung from a common though remote origin. Thus all the numerous languages spoken by the American Indians, or red men, are similar in grammatical structure: an intimate analogy exists in the languages of the Esquimaux nations who inhabit the Arctic regions of both continents. Dialects of one tongue are spoken throughout N.

---

[1] Their average height is about 6 ft., with individuals rather taller than this.—Darwin, *Naturalist's Voyage*, p. 282.

Africa, as far S. as the oasis of Siwah on the E., and the Canary Islands on the W. Another group of cognate idioms is common to the inhabitants of Equatorial Africa, while all the S. part of the continent is inhabited by people whose languages are connected. The monosyllabic speech of the Chinese and Indo-Chinese shows that they are the same people; and all the insular nations of the Pacific derived their dialects from some tribes on the continent of India and the Indian Archipelago. Cognate tongues are spoken by the Tartars, Mandchus, Fins, Laplanders, many of the Siberian tribes, and by the Hungarians. The Syro-Arabian, or Semitic languages, as the Chaldee, Arabic, and Hebrew, are evidently, from their grammatical construction, of the same origin.

The Persian, Greek, Latin, German, and Celtic tongues are connected by grammatical structure, and words expressive of the same objects and feelings, with the Sanscrit, or sacred language of India; consequently the nations inhabiting that vast extent of country from the mouth of the Ganges to the British Isles, the coast of Scandinavia and Iceland, are concluded to have had the same origin. The original stock of this most highly endowed family of nations is now, by common consent, termed Aryans, and their original seat is considered to have been among the high lands about the head waters of the Oxus.

Notwithstanding the number of allied tongues, all attempts to trace them to a common origin have failed, which evidently proves that each race formed its own. The formation of language is adduced by Mr. Crawfurd as one of the many facts which attest the high antiquity of man. 'Language is not innate, but adventitious; a mere acquirement, having its origin in the superiority of the human understanding, like any other acquisition derived from the same source. Infants are without language; they gradually acquire it as they improve in intelligence. Children learn any language with equal facility; they can forget their mother tongue and learn another. Among the unquestionable proofs that language is not innate is the prodigious number of languages which exist, some with a very narrow range of articulate sounds, others with a very wide one; some words confined to single syllables, and others having many; some being of very simple and others of a very complicated structure.' Thus, language combines with geology in bearing testimony to the vast antiquity of the human race. That man has existed on earth immeasurably anterior to historical record there can be little doubt, since no absolute date can be assigned for the antiquity of the historical period prior, for instance, to the establishment in the valley of the Nile of a nation so highly advanced in civilisation as the ancient Egyptians. It is obvious that innumerable centuries are required for the slow, spontaneous

growth of civilisations like that of the Pharaohs. Moreover, the discovery of implements of bone and flint in caverns under conditions which show that a race existed in W. Europe at that remote epoch when an Arctic climate reigned in Central France, and the reindeer abounded, places the great antiquity of our race beyond a doubt. Nor was this the earliest date of man's existence, for flint implements have been found embedded in drift beds which were deposited at an early epoch, as is indicated by the facts that the rivers of N. France have since worn down their valleys 200 ft., and the Solent has gradually worn through its passage between the Isle of Wight and Hampshire.

§ 3. **European nations.**—The prevailing races of mankind now inhabiting Europe are the Teutonic, Celtic, and Sclavonian. In the greater part of the continent these races are mixed, but the blood is purely Teutonic throughout Iceland, Scandinavia, round the Gulf of Bothnia, in Denmark, Germany, and the E. of England from Portsmouth to the Tyne. Pure Celtic blood is confined to the Basque provinces in Spain, the S. and S.W. of France, a part of the Grisons in Switzerland, and the W. parts of the British Islands. The Sclavonian blood is widely dispersed in middle Russia, from the Ural Mountains to the W. of the Valdai tableland, and from Novogorod to the countries bordering on the lower course of the Don. The 3 races have been much improved by mixture, in appearance, energy, and versatility of mind.

At present the Teutonic race, including the inhabitants of North America and the British colonies, considerably outnumbers the Celtic, though far inferior in ancient times. The Teutonic variety has subdued and even exterminated the other varieties in its progress towards the W.; it is undoubtedly the most vigorous, both in body and mind, of all mankind, and seems destined to conquer and civilise the whole world. It is a singular fact, whatever the cause may be, that the Celts are invariably Roman Catholic, while the Teutonic population is inclined to Protestantism, which consequently will go on increasing in its spread over the world with the intellectual race that professes it.

Various other races inhabit Europe, inferior in numbers to those above mentioned, though occasionally mixed with them, as the Turks, Fins, the Samojedes, who live on the shores of the White Sea and in the N.E. of Russia, and the Hungarians, the higher class of whom are a fine race of men, and on a par with the most civilised of the European nations.[1] There are many mixed Tartar

[1] To explain which we must bear in mind that Europe had been inhabited before the arrival of the Asiatic tribes, consequently some of the inhabitants of the more remote regions are probably the aborigines of the country.

tribes, chiefly in the S. and E. of the Russian territories; also Jews and Gipsies, who live among all nations, yet mix little with any.[1]

The inhabitants of Great Britain are of Celtic and Teutonic origin. The Celtic blood is purest in Cornwall and the Scilly Islands, in Wales, and the Isle of Man: in the highlands of Scotland and the Hebrides it is more mixed than is generally supposed, as plainly appears from the frequency of red hair and blue eyes. In some parts of Ireland there is pure Celtic blood, but throughout the greater part of that country it is mixed, although the Celtic character predominates; but in Ulster, where the earliest colony settled, the blood is Teutonic. In Ireland the difference in the organisation of the two races is strongly marked: placed under the same circumstances the Teutonic part of the population has prospered which, unfortunately, has not been the case, to the same extent, with the Celtic.

The *dialects* spoken in the Celtic districts are closely allied to the Semitic languages of Asia, and to one another. The Cornish is worn out, the Manx is nearly so, and the Gaelic is declining fast in the Hebrides and highlands of Scotland.

The races of mankind are equally distinguished from one another by their *religious opinions*. Europe is Christian; Catholicism is the faith in the S.W.; and it has been observed that, wherever the spoken language is derived from that of ancient Rome, the creed of modern Rome prevails. In the E. of Europe the Sclavonians are of the Greek Church, and in N. and Central Europe the people are Protestant. From the Atlantic along the N. coast of Africa, and from Turkey in Europe through Persia to India, the inhabitants are for the most part Mohammedans; Brahminism, Buddhism, and other forms of idolatry prevail through the rest of the Asiatic continent.

In the Central States and the British provinces of North America, the great proportion of the population is Protestant; Mexico and a large portion of South America are nominally Catholic; and the rest of the southern continent, with a few exceptions, is in the lowest state of barbarism.

§ 4. **Diversities of Form and Colour in the Human Race.**—Ethnologists are not at present in accord regarding the origin of the varieties of the human race. A desultory discussion has been carried on for many years on the question whether man

---

[1] EUROPEAN POPULATION.

Pure blood, about	174,500,000
Mixed blood in Europe	134,678,300
Total population of Europe, pure and mixed	309,178,300

had one only, or many origins; or, as it is generally put whether there are one or many species of the genus *homo*. In the absence of any definition of the term 'species,' and of explanation of what is understood by 'origin,' such discussions can bear but little fruit, and in fact they are injurious to the best interests of science, as diverting the attention from the investigation of the causes which have produced the differences between nations and races. No problems in biological science seem farther from solution than the causes of the diversity in form, colour, mental disposition, and so forth, of mankind. Many instances have occurred in modern times of albinos and red haired children having been born of black parents, and these have transmitted their peculiarities to their descendants for several generations; but it is extremely doubtful whether pure blooded white parents have produced a black offspring. The varieties are much more likely to have arisen from the effects of climate, food, customs, and civilisation upon migratory groups of mankind; and of such, a few instances have occurred in historical times, limited, however, to small numbers and particular spots; but the great mass of nations had received their distinctive characters at a very early period, for there is no instance on record of a new variety having been established as a nation.

Other causes than the sun must have been combined to occasion all the varieties we now see, otherwise every nation between the tropics would be of the same hue, whereas the sooty negro inhabits equatorial Africa, the red man equinoctial America, and both are mixed with fairer tribes. In Asia, the Rohillas, a fair race of Affghan extraction, inhabit the plains N. of the Ganges; the Bengalee and the mountaineers of Nepal are dark, and the Mahrattas are yellow. The complexion of man varies also with height above the sea and the latitude of the region he lives in; some of the inhabitants of the Himalayas and Hindu Kush are fair, and even a red haired race is found on the latter. There are fair haired people with blue eyes in the Ruddhua Mountains in Africa. The Kabyles, that inhabit the country behind Tunis and Algiers, are similar in complexion to the nations in N. latitudes. This correspondence, however, holds good only with regard to the N. hemisphere, for it is a well known fact that the varieties of the numerous species in the S. continents are much more similar in physical characters to the native races of the torrid zone than any of the aboriginal people of the N. regions. Even supposing that diversity of colour is owing to the sun's rays only, it is scarcely possible to attribute to them the thick lips, the woolly hair, and the difference of form, extending even to the bones and the skull.

§ 5. **Flexibility of the Human Constitution favourable to the Diffusion of Man.**—The flexibility of man's constitution enables him to live in every climate, from the equator to the ever-frozen coasts of Novaia Zemlia and Spitzbergen, and that chiefly by his capability of bearing the most extreme changes of temperature and diet, which are probably the principal causes of the variety in his form. It has already been mentioned that chemical action is the cause of vital force and heat in man and animals. The quantity of food must be in proportion to the quantity of oxygen inhaled, otherwise disease and loss of strength would be the consequence. Since cold air is incessantly carrying off warmth from the skin, more exercise is requisite in winter than in the summer, in cold climates than in warm; consequently more carbon is necessary in the former than in the latter, in order to maintain the chemical action that generates heat and to ward off the destructive effects of the oxygen, which is incessantly at work in consuming the body. Animal food, wine, and spirits contain more carbon than fruit and vegetables, therefore they are much more necessary in a cold than in a hot climate. The Esquimaux, who lives by the chase and eats 10 or 12 pounds of meat and fat in 24 hours, finds it not more than enough to keep up his strength and animal heat, while the indolent inhabitant of Bengal is sufficiently supplied with both by his rice diet. Clothing and warmth render the necessity for exercise and food much less by diminishing the waste of animal heat. Hunger and cold united soon consume the body, because it loses its power of resisting the action of the oxygen, which consumes part of our substance when food is wanting. Hence nations inhabiting warm climates have no great merit in being abstemious, nor can those be considered guilty of committing an excess who live more freely in colder countries. The arrangement of Divine Wisdom is to be admired in this as in all other things, for, if man had only been capable of living on vegetable food, he never could have had a permanent residence beyond the latitude where corn ripens. The Esquimaux and all the inhabitants of very high latitudes of both continents live entirely on fish and animal food. What effects the difference of food may have upon the intellect it is difficult to determine.

A nation or tribe driven by war or any other cause from a warm to a cold country, or the contrary, would be forced to change their food both in quality and quantity, which in the lapse of ages might produce an alteration in the external form and internal structure. The probability is still greater if the entire change that a few years produce in the matter of which the human frame is composed be considered. At every instant during life, with every motion, voluntary and involuntary, with every thought and every exercise

of the brain, a portion of our substance becomes dead, separates from the living part, combines with some of the inhaled oxygen, and is removed. By this process it is supposed that the whole body is renewed every seven years. Every change of food, climate, and mental excitement must have its influence on the reproduction of the mortal frame; and thus a thousand causes may co-operate to alter whole races of mankind placed under new circumstances, time being granted.

The difference between the effects of manual labour and the efforts of the brain appears in the intellectual countenance of the educated man, compared with that of the peasant, though even he is occasionally stamped with nature's own nobility. The most savage people are also the ugliest. Their countenance is deformed by violent unsubdued passions, anxiety, and suffering. Deep sensibility gives a beautiful and varied expression, but every strong emotion is unfavourable to perfect regularity of feature; and of that the Greeks were well aware when they gave that calmness of expression and repose to their unrivalled sculpture. The refining effects of high culture, by subduing the evil passions and encouraging the good, are more than anything calculated to improve even the external appearance. The countenance, though perhaps of less regular form, becomes expressive of the amiable and benevolent feelings of the heart, the most captivating and lasting of all beauty.[1]

Thus an infinite assemblage of causes may be assigned as having produced the endless varieties in the human race: the fact remains an inscrutable mystery, the more so as the permanency of type is one of the most striking circumstances, and proves the length of time necessary to produce a change in natural structure and colour. The national appearance of the Ethiopians, Persians, and Jews, has not varied for more than 3000 years, as appears from the ancient Egyptian paintings in the tomb of Rhamses the Great, discovered at Thebes by Belzoni, in which the countenances of the modern Ethiopian and Persian can be readily recognised, and the Jewish features and colour are identical with those of the Israelites daily met with in the streets of London. The unaltered state of the two former may perhaps be attributed to the unchanged circumstances and climate in which they have lived; not so with

---

[1] The countenances of the Fuegians brought to England in 1830 by Captain Fitzroy improved greatly in expression by their intercourse with civilised men, but they had not returned to their savage brethren more than a year before their whole appearance was completely changed; the look of intelligence they had acquired was gone; and when compared with likenesses that had been taken of them when in England, they were not to be recognised as the same persons.

regard to the Jews, who, though they have become fair in some parts of Europe, retain a permanency of type not to be mistaken.

§ 6. **Centres of Civilisation.**—It is supposed that the seats of the earliest discernible civilisations were the mountainous parts of the continents, whence the divers tribes descended and diffused themselves gradually, as geological causes permitted the low lands to be habitable, so that the diffusion became an index of geological changes.

Animals and vegetables, being the sources of man's sustenance, have had the chief influence on his destiny and location, and have induced him to settle in those parts of the world where he could procure them in greatest abundance. Wherever the chase or the spontaneous productions of the earth supply him with food, he is completely savage, and only a degree further advanced where he plants the palm and the banana; where grain is the principal food, industry and intelligence are most perfectly developed, as in the temperate zone. On that account the centres of civilisation have generally been determined, not by a hot, but by a genial climate, fertile soil, by the vicinity of the sea coast or great rivers, affording the means of fishing and transport, which last has been one of the chief causes of the superiority of Europe and S. Asia. The mineral treasures of the earth have been the means of assembling large masses of men in Siberia, on the table-land of the Andes, in California, Australia, and British Columbia, and have given rise to many large cities both in the Old and the New World. Nations inhabiting high ungenial latitudes have often been driven there by war, or obliged to wander from countries where the population exceeded the means of existence—a cause of migration to which both language and tradition bear testimony. The belief in a future state, so universal, shown by respect for the dead, has no doubt been transmitted from nation to nation. The American Indians, driven from their hunting grounds, still make pilgrimages to the tombs of their fathers; and these tribes alone, of all uncivilised mankind, worship the Great Spirit as the invisible God and Father of all.

It is probable that America was peopled from Asia before the separation of the continents by Behring Strait, or at any rate at an epoch when a milder climate existed in that latitude than now prevails there. Probably a race of mankind had migrated from France to Britain before the English Channel was formed: and there is reason to suppose that the location of various races of mankind, now insulated, may have taken place before the separation of the lands by mediterranean seas; whilst others, previously insulated, may be now united by the drying up of inland seas, as those which covered the Saharan Desert and the great hollow

round the Caspian Sea, of which it and the Black Sea are the remnants. It was probably at that period that N. Africa was peopled by tribes which descended from the high lands of Senegambia and Abyssinia.

From the earliest period of the peopling of the earth by man, a never ceasing process of migration has in all probability been going on. In Europe we may dimly see by the light of history and the signs of earlier races revealed by buried bones, weapons, and implements, that wave after wave of population has spread over the land; the earlier races being either exterminated, driven into remote corners of the continent, or amalgamated with the new comers. This, it is fair to assume, has been the case over the whole earth. The successive re-peoplings of countries and continents cannot have been effected without prolonged life and death struggles, resulting in the victory of the more vigorous and intelligent race, and thus a population of higher mark than the preceding one has, time after time, overspread the land. How the new invaders have acquired their superior qualities, corporeal and mental, is a subject for the investigation of ethnologists and philosophers. It is probable they have slowly grown in limited districts, under the influence of favourable local conditions, and possibly of some few able men happily born among them. An active spirit or a population outgrowing the means of subsistence are the incentives to migration and conquest; the improved race is thus widely spread, and fresh and improved developments again take place in limited portions of the newly peopled area.

M. Boué has observed that mountain chains running nearly E. and W. establish much more striking differences among nations than those which extend from N. to S.—a circumstance confirmed by observation through the history of mankind. The Scandinavian Alps have not prevented the countries on both sides from being occupied by people of a common descent; while the feeble barrier of the Cheviot Hills, between England and Scotland, and the moderate elevation of the Highland mountains, have prevented the amalgamation of the Anglo Saxons and the Celts, even in a period of high civilisation. The Franks and Belgians are distinct, though separated by hills of still less elevation. For the same reason the Spaniards and Italians differ far more from their neighbours on the other side of the eastern and western chains than the Spaniards do from the Portuguese, or the Piedmontese from the Provençals. A similar distinction prevails throughout Asia; and in America, where all the principal chains run N. and S., there is but one copper coloured race throughout the continent, which stretches over more climates than Europe or Africa, or even than Asia and Australia united. It is in general along chains running

N. and S. that the fusion of language takes place, and not along those of an E. and W. direction. From Poland, for instance, there are intermediate insensible gradations through Germany into France; while in crossing from a German district of the Alps to the valleys of Italy, different tribes and different languages are separated by a single mountain. Even wars and conquest have ever been more easy in one direction than in the other. The difference in the fauna and flora on the two sides of the great tablelands and mountains of Asia is a striking illustration of the influence which high lands running E. and W. have on natural productions, and thus, both directly and indirectly, they affect the distribution of mankind.

The circumstances which thus determine the location of nations, and the fusion or separation of their languages, must, conjointly with moral causes, operate powerfully on their character. The minds of mankind, as well as their fate, are influenced by the soil on which they are born and bred. The natives of elevated countries are attached to their mountains; the Dutch are as much attached to their meadows and canals; and the savage, acquainted only with the discomforts of life, is unhappy when brought amongst civilised man. Early associations never entirely leave us, however much our position in life may alter; and strong attachments are formed to places which generate in us habits differing from those of other countries.

§ 7. **Influences of outward circumstances on Man, and Man's influence on Nature.**—The Baltic and Mediterranean Seas have had no inconsiderable share in civilising Europe; one combined with a cold and gloomy climate, the other with a warm and glowing sky, have developed dissimilar characters in the temperament and habits of the surrounding nations, originally dissimilar in race. The charms of climate and the ease with which the necessaries of life are procured were favourable to the development of imagination in the more S. nations, and to an indolent enjoyment of their advantages. In the N., on the contrary, the task imposed upon man was harder, and perhaps more favourable to strength of character. The Dutch owe their industry and perseverance to their unceasing struggle against the encroachments of the ocean; the British are indebted to their insular position for their maritime character, and to the small extent of their country and the richness of their mines for their manufacturing and colonising habits; the military propensities of the French are owing to the necessity of maintaining their independence among the surrounding nations, as well as to ambition and the love of fame. Thus external circumstances materially modify the character of nations, but the original propensities of race are never eradicated.

The power of external circumstances over man is not greater than his influence on the material world. He cannot create power, it is true, but he dexterously avails himself of the powers of nature to subdue nature. Air, fire, water, steam, gravitation, electricity, his own muscular strength, and that of animals rendered obedient to his will, are the instruments by which he has converted the desert into a garden, drained marshes, cut canals, made roads, turned the courses of rivers, opened communications, cleared away forests in one country, planted them in another, and compelled the dread lightning to bear his messages through the air, the earth, and even the deep waters. By these operations he has altered the climate, changed the course of local winds, increased or diminished the quantity of rain, and softened the rigour of the seasons. In the time of Strabo the cold in France was so intense that it was thought impossible to ripen grapes N. of the mountains of the Cevennes: the Rhine and the Danube were every winter covered with ice thick enough to bear any weight. Man's influence on vegetation has been immense, and it is chiefly through his tendency to cut down forest trees, the natural clothing of the land, that he has produced the greatest amount of change on the surface of the earth. Forests in warm climates are essential to the fertility of a country. They act as a regulator of the annual rainfall, by preventing too rapid evaporation from the soil, and creating a stratum of cooler atmosphere above it; the effect of these functions being that the amount of rain falling is moderated and spread over a greater number of days. In warm countries like Australia, Arabia, some parts of S. Europe, and India, districts which have no clothing of trees, or have been deprived of it by the hand of man, the rainfall descends in sudden deluges and the dry seasons are excessively prolonged. Thus the violent rain wash prevents the accumulation of humus or fertile soil, and the surface of the earth is scorched to sterility by months of fierce sun. In the S. of France the deterioration of climate by felling the timber on the hill slopes has been distinctly observed during the past century, and legislative enactments have been found necessary to protect what remains and restore what has been lost.[1] It is probable that whole countries in Asia Minor, Syria, Mesopotamia, and N. Africa, would have had another destiny since classic times, had a more intelligent practice been followed regarding the forests which they once formerly possessed. Man has adapted many natural products to his wants, and made them the instruments of his advancement. The olive, the vine, and the fig tree have been cultivated time

---

[1] Consult the excellent work by Mr. G. P. Marsh, 'Man and Nature; or, Physical Geography as modified by Human Action.'

immemorial; wheat, rice, and barley have been so long in an artificial state that their origin is unknown; even maize, which is an American plant, was in use among the tribes of that continent before the Spanish conquest; and tobacco was already used by them to allay the pangs of hunger, to which those who depend upon the chase for food must be exposed. Most of the ordinary culinary vegetables have been known for ages, and it is remarkable that in these days, when our gardens are adorned with innumerable native plants in a cultivated state, few new grains, vegetables, or fruits, have been reclaimed; the old have been produced in infinite variety, and many new brought from foreign countries.

§ 8. **Domestication of Animals, &c.**—Animals yield more readily to man's influence than vegetables, and certain classes have greater flexibility of disposition and structure than others. Those only are capable of being perfectly reclaimed that have a natural tendency for it, without which man's endeavours would be unavailing. This predisposition is greatest in animals which are gregarious and follow a leader, as elephants, dogs, horses, and cattle do in their wild state; yet even among these some species are refractory, as the buffalo, which can only be regarded as half reclaimed. The canine tribe, on the contrary, are capable of the greatest attachment: not the dog only, man's faithful companion, but even the wolf and the hyæna, generally so ferocious. After an absence of many months, a hyæna, which had been the fellow-passenger of a friend of the author in a voyage from India, recognised his voice before he came in sight, and on seeing him showed the greatest joy, lay down like a dog, and licked his hands. He had been kind to it on the voyage, and no animal forgets kindness, which is the surest way of reclaiming them. There cannot be a greater mistake than the harsh and cruel means by which dogs and horses are too commonly trained; but it is long before man learns that his power is mental, and that it is intellect alone that has given him dominion over the earth and its inhabitants, of which so many far surpass him in physical strength. The useful animals were reclaimed by the early inhabitants of Asia, and it is very remarkable, notwithstanding the enterprise and activity of the present times, that among the multitude of animals that inhabit America, Central and S. Africa, Australia, and the Indian Archipelago, four only have been domesticated, yet many may be capable of becoming useful to man. Of 35 species of which we possess one or more domestic races, 31 are natives of Asia, Europe, and N. Africa; these countries are far from being exhausted, and an entire hemisphere is yet but very partially explored. An attempt has been made to domesticate the llama, the dziggetai, zebra, and some species of Indian deer, but the success is very

problematical. Little has been left for modern nations but the improvement of the species, and in that they have been very successful. The variety of horses, dogs, cattle, and sheep, is beyond number. The form, colour, and even the disposition, may be materially altered, and the habits engrafted are transmitted to the offspring, as instinctive properties independent of education. Domestic fowls go in flocks on their native meads when wild. There are, however, instances of solitary birds being tamed to an extraordinary degree, as the raven, one of the most sagacious.

Man's necessities and enjoyments have been the cause of great changes in the animal creation, and his destructive propensity of still greater. A farmer sees the rooks pecking a little of his grain, or digging at the roots of the springing corn, and poisons all in his neighbourhood. A few years after he is surprised to find his crop destroyed by grubs. The works of the Creation are nicely balanced, and man cannot infringe the laws of equilibrium with impunity. Insects would become torments were they not kept in check by birds. Animals soon acquire a dread of man, which becomes instinctive and hereditary: in newly discovered uninhabited countries birds and beasts are so tame as to allow themselves to be caught; whales scarcely got out of the way of the ships that first navigated the Arctic Ocean, but now they universally have a dread of the common enemy: whales and seals have been extirpated in various places: sea fowl and birds of passage are not likely to be extinguished, but many land animals and birds are disappearing before the advance of civilisation. Drainage, cultivation, cutting down of forests, and even the introduction of new plants and animals, destroy some of the old and alter the relations between those that remain. The inaccessible cliffs of the Himalayas and Andes will afford a refuge to the eagle and condor, but the time will come when the mighty forests of Bhutan, of the Amazon and Orinoco, will disappear with the myriads of their joyous inhabitants.

This time is at present, however, extremely remote. It is true that the process of occupying and replenishing the earth, by the most active and restless section of our species, is advancing with accelerating rapidity. All the remaining central part of one of the largest continents of the earth is now fast filling up with civilised inhabitants. It is mapped into states, territories, and counties, and a line of iron road, over which pants the irresistible locomotive, spans the wide region from ocean to ocean. A vast migration streams from the shores of Europe to this rapidly advancing new continent. In the other hemisphere, too, Australia and New Zealand are fast becoming peopled by the same process. But it will be long indeed before the whole of the fertile land of the earth is occupied by a progressive, civilised people. The great

interior plains of South America alone would sustain a larger population than China, and at present their inhabitants are only in the proportion of one to four square miles of territory. The enervating climate of the country will render the settlement of this great region by the Caucasian race an extremely slow process. The same may be said of the intractable continent of Africa, which possesses a wide region of comparatively healthy upland in its broad interior, but which offers, in the deadly climate of its coast lands, a formidable obstacle to the occupation of the better tracts by a higher race than has now the possession of the land. The natural forest clothing of a great portion of these continents, with its myriads of curious and beautiful forms of animal and vegetable life, is destined probably to disappear, and man alone, with his cultivated plants and domesticated animals, will occupy the place of the natural tenants: but there will remain many a rugged valley in the lofty mountain ranges, and many a league of inaccessible swamp, to serve as a refuge for a large portion of the native faunas and floras. We may hope, moreover, that, with the increase of wealth, leisure, knowledge, and refinement, which happily seems a secure prospect for the long vistas of the future, man will endeavour to preserve the equilibrium which exists in the meteorological forces and vital conditions of countries, when in their natural state, by fostering a due proportion of woodland, and thus save from extinction the myriad beauteous forms of life which have shared with him the inheritance of this wonderful earth.

INDEX.

LONDON: PRINTED BY
SPOTTISWOODE AND CO., NEW-STREET SQUARE
AND PARLIAMENT STREET

MR. MURRAY'S
GENERAL LIST OF WORKS.

ABINGER'S (LORD Chief Baron of the Exchequer) Life. By the Hon. P. CAMPBELL SCARLETT. Portrait. 8vo.

ALBERT MEMORIAL. A Descriptive and Illustrated Account of the National Monument erected to the PRINCE CONSORT at Kensington. Illustrated by Engravings of its Architecture, Decorations, Sculptured Groups, Statues, Mosaics, Metalwork, &c. With Descriptive Text. By DOYNE C. BELL. With 24 Plates. Folio. 12*l*. 12*s*.

——— (PRINCE) SPEECHES AND ADDRESSES, with an Introduction, giving some outline of his Character. With Portrait. 8vo. 10*s*. 6*d*.; or *Popular Edition*, fcap. 8vo. 1*s*.

ALBERT DÜRER; his Life, with a History of his Art. By DR. THAUSING, Keeper of Archduke Albert's Art Collection at Vienna. Translated from the German. With Portrait and Illustrations. 2 vols. 8vo. [*In the Press*.

ABBOTT'S (REV. J.) Memoirs of a Church of England Missionary in the North American Colonies. Post 8vo. 2*s*.

ABERCROMBIE (JOHN). Enquiries concerning the Intellectual Powers and the Investigation of Truth. Fcap. 8vo. 3*s*. 6*d*.

——— Philosophy of the Moral Feelings. Fcap. 8vo. 2*s*. 6*d*.

ACLAND (REV. CHARLES). Popular Account of the Manners and Customs of India. Post 8vo. 2*s*.

ÆSOP'S FABLES. A New Version. With Historical Preface. By Rev. THOMAS JAMES. With 100 Woodcuts, by TENNIEL and WOLF. Post 8vo. 2*s*. 6*d*.

AGRICULTURAL (ROYAL) JOURNAL. (*Published half-yearly*.)

AIDS TO FAITH: a Series of Theological Essays. By various Authors. 8vo. 9*s*.

Contents:—Miracles; Evidences of Christianity; Prophecy & Mosaic Record of Creation; Ideology and Subscription; The Pentateuch; Inspiration; Death of Christ; Scripture and its Interpretation.

AMBER-WITCH (THE). A most interesting Trial for Witchcraft. Translated by LADY DUFF GORDON. Post 8vo. 2*s*.

ARMY LIST (THE). *Published Monthly by Authority.*

ARTHUR'S (LITTLE) History of England. By LADY CALLCOTT. *New Edition, continued to* 1872. With 36 Woodcuts. Fcap. 8vo. 1*s*. 6*d*.

AUSTIN (JOHN). LECTURES ON GENERAL JURISPRUDENCE; or, the Philosophy of Positive Law. Edited by ROBERT CAMPBELL. 2 Vols. 8vo. 32*s*.

——— STUDENT'S EDITION, by ROBERT CAMPBELL, compiled from the above work. Post 8vo. 12*s*.

——— Analysis of. By GORDON CAMPBELL, M.A. Post 8vo.

ARNOLD (THOS.). Ecclesiastical and Secular Architecture of Scotland: The Abbeys, Churches, Castles, and Mansions. With Illustrations. Medium 8vo. [*In Preparation*.

ATKINSON (DR. R.) Vie de Seint Auban. A Poem in Norman-French. Ascribed to MATTHEW PARIS. With Concordance, Glossary, and Notes. Small 4to, 10*s.* 6*d.*

ADMIRALTY PUBLICATIONS; Issued by direction of the Lords Commissioners of the Admiralty:—

A MANUAL OF SCIENTIFIC ENQUIRY, for the Use of Travellers. *Fourth Edition.* Edited by ROBERT MAIN, M.A. Woodcuts. Post 8vo. 3*s.* 6*d.*

GREENWICH ASTRONOMICAL OBSERVATIONS 1841 to 1846, and 1847 to 1871. Royal 4to. 20*s.* each.

MAGNETICAL AND METEOROLOGICAL OBSERVATIONS. 1840 to 1847. Royal 4to. 20*s.* each.

APPENDICES TO OBSERVATIONS.

1837. Logarithms of Sines and Cosines in Time. 3*s.*
1842. Catalogue of 1439 Stars, from Observations made in 1836 to 1841. 4*s.*
1845. Longitude of Valentia (Chronometrical). 3*s.*
1847. Description of Altazimuth. 3*s.*
Twelve Years' Catalogue of Stars, from Observations made in 1836 to 1847. 4*s.*
Description of Photographic Apparatus. 2*s.*
1851. Maskelyne's Ledger of Stars. 3*s.*
1852. I. Description of the Transit Circle. 3*s.*
1853. Refraction Tables. 3*s.*
1854. Description of the Zenith Tube. 3*s.*
Six Years' Catalogue of Stars, from Observations. 1848 to 1853. 4*s.*
1862. Seven Years' Catalogue of Stars, from Observations. 1854 to 1860. 10*s.*
Plan of Ground Buildings. 3*s.*
Longitude of Valentia (Galvanic). 2*s.*
1864. Moon's Semid. from Occultations. 2*s.*
Planetary Observations, 1831 to 1835. 2*s.*
1868. Corrections of Elements of Jupiter and Saturn. 2*s.*
Second Seven Years' Catalogue of 2760 Stars for 1861 to 1867. 4*s.*
Description of the Great Equatorial. 3*s.*
1856. Descriptive Chronograph. 3*s.*
1860. Reduction of Deep Thermometer Observations. 2*s.*
1871. History and Description of Water Telescope. 3*s.*

Cape of Good Hope Observations (Star Ledgers). 1856 to 1863. 2*s.*
—————— 1856. 5*s.*
—————— Astronomical Results. 1857 to 1858. 5*s.*

Report on Teneriffe Astronomical Experiment. 1856. 5*s.*

Paramatta Catalogue of 7385 Stars. 1822 to 1826. 4*s.*

ASTRONOMICAL RESULTS. 1847 to 1871. 4to. 3*s.* each.

MAGNETICAL AND METEOROLOGICAL RESULTS. 1847 to 1871. 4to. 3*s.* each.

REDUCTION OF THE OBSERVATIONS OF PLANETS. 1750 to 1830. Royal 4to. 20*s.* each.

—————— LUNAR OBSERVATIONS. 1750 to 1830. 2 Vols. Royal 4to. 20*s.* each.

—————— 1831 to 1851. 4to. 10*s.* each.

BERNOULLI'S SEXCENTENARY TABLE. 1779. 4to. 5*s.*

BESSEL'S AUXILIARY TABLES FOR HIS METHOD OF CLEARING LUNAR DISTANCES. 8vo. 2*s.*

ENCKE'S BERLINER JAHRBUCH, for 1830. *Berlin*, 1828. 8vo. 9*s.*

HANSEN'S TABLES DE LA LUNE. 4to. 20*s.*

LAX'S TABLES FOR FINDING THE LATITUDE AND LONGITUDE. 1821. 8vo. 10*s.*

LUNAR OBSERVATIONS at GREENWICH. 1783 to 1819. Compared with the Tables, 1821. 4to. 7*s.* 6*d.*

ADMIRALTY PUBLICATIONS—*continued.*

MACLEAR ON LACAILLE'S ARC OF MERIDIAN. 2 Vols. 20*s.* each.

MAYER'S DISTANCES of the MOON'S CENTRE from the PLANETS. 1822, 3*s.*; 1823, 4*s.* 6*d.* 1824 to 1835. 8vo. 4*s.* each.

——— TABULÆ MOTUUM SOLIS ET LUNÆ. 1770. 5*s.*

——— ASTRONOMICAL OBSERVATIONS MADE AT GOTTINGEN, from 1756 to 1761. 1826. Folio. 7*s.* 6*d.*

NAUTICAL ALMANACS, from 1767 to 1877, 80*s.* 2*s.* 6*d.* each.

——— SELECTIONS FROM, up to 1812. 8vo. 5*s.* 1834-54. 5*s.*

——— SUPPLEMENTS, 1828 to 1833, 1837 and 1838. 2*s.* each.

——— TABLE requisite to be used with the N.A. 1781. 8vo. 5*s.*

SABINE'S PENDULUM EXPERIMENTS to DETERMINE THE FIGURE OF THE EARTH. 1825. 4to. 40*s.*

SHEPHERD'S TABLES for CORRECTING LUNAR DISTANCES. 1772. Royal 4to. 21*s.*

——— TABLES, GENERAL, of the MOON'S DISTANCE from the SUN, and 10 STARS. 1787. Folio. 5*s.* 6*d.*

TAYLOR'S SEXAGESIMAL TABLE. 1780. 4to. 15*s.*

——— TABLES OF LOGARITHMS. 4to. 60*s.*

TIARK'S ASTRONOMICAL OBSERVATIONS for the LONGITUDE of MADEIRA. 1822. 4to. 5*s.*

——— CHRONOMETRICAL OBSERVATIONS for DIFFERENCES of LONGITUDE between DOVER, PORTSMOUTH, and FALMOUTH. 1823. 4to. 5*s.*

VENUS and JUPITER: OBSERVATIONS of, compared with the TABLES. *London*, 1822. 4to. 2*s.*

WALES' AND BAYLY'S ASTRONOMICAL OBSERVATIONS. 1777. 4to. 21*s.*

——— REDUCTION OF ASTRONOMICAL OBSERVATIONS MADE IN THE SOUTHERN HEMISPHERE. 1764—1771. 1788. 4to. 10*s.* 6*d.*

BARBAULD (MRS.). Hymns in Prose for Children. With Illustrations. Crown 8vo. 5*s.*

BARKLEY (H. C.). Five Years among the Bulgarians and Turks between the Danube and the Black Sea. Post 8vo. 10*s.* 6*d.*

BARROW (SIR JOHN). Autobiographical Memoir, from Early Life to Advanced Age. Portrait. 8vo. 16*s.*

——— (JOHN) Life, Exploits, and Voyages of Sir Francis Drake. Post 8vo. 2*s.*

BARRY (SIR CHARLES). Life and Works. By CANON BARRY. With Portrait and Illustrations. Medium 8vo. 15*s.*

BATES' (H. W.) Records of a Naturalist on the River Amazon during eleven years of Adventure and Travel. Illustrations. Post 8vo. 7*s.* 6*d.*

BAX (CAPT. R.N.). Russian Tartary, Eastern Siberia, China, Japan, and Formosa. A Narrative of a Cruise in the Eastern Seas. With Map and Illustrations. Crown 8vo. 12*s.*

BEAUCLERK (LADY DIANA). Summer and Winter in Norway. With Illustrations. Small 8vo. 6*s.*

BELCHER (LADY). Account of the Mutineers of the 'Bounty,' and their Descendants; with their Settlements in Pitcairn and Norfolk Islands. With Illustrations. Post 8vo. 12*s.*

BELL'S (SIR CHAS.) Familiar Letters. Portrait. Post 8vo. 12*s.*

BELL (DOYNE C.). Notices of the Historic Interments in the Church of St. Peter ad Vincula, in the Tower of London, with an account of the discovery of the remains of Queen Anne Boleyn. With Illustrations. Crown 8vo. [*In the Press.*

BELT'S (THOS.) Naturalist in Nicaragua, including a Residence at the Gold Mines of Chontales; with Journeys in the Savannahs and Forests; and Observations on Animals and Plants. Illustrations. Post 8vo. 12*s.*

BERTRAM'S (JAS. G.) Harvest of the Sea: an Account of British Food Fishes, including sketches of Fisheries and Fisher Folk. With 50 Illustrations. 8vo. 9*s.*

BIBLE COMMENTARY. EXPLANATORY and CRITICAL. With a REVISION of the TRANSLATION. By BISHOPS and CLERGY of the ANGLICAN CHURCH. Edited by F. C. COOK, M.A., Canon of Exeter. VOLS. I. to VI. (The Old Testament). Medium 8vo. 6*l.* 15*s.*

Vol. I. 30*s.*	GENESIS. EXODUS. LEVITICUS. NUMBERS. DEUTERONOMY.	VOL. IV. 24*s.*	JOB. PSALMS. PROVERBS. ECCLESIASTES. SONG OF SOLOMON.
Vols. II. and III. 36*s.*	JOSHUA, JUDGES, RUTH, SAMUEL, KINGS, CHRONICLES, EZRA, NEHEMIAH, ESTHER.	Vol. V. 20*s.*	ISAIAH. JEREMIAH.
		Vol. VI. 25*s.*	EZEKIEL. DANIEL. MINOR PROPHETS.

BIGG-WITHER (T. P.). Pioneering in S. Brazil; three years of forest and prairie life in the province of Parana. Map and Illustrations. 8vo. [*In the Press.*

BIRCH'S (SAMUEL) History of Ancient Pottery and Porcelain: Egyptian, Assyrian, Greek, Roman, and Etruscan. With Coloured Plates and 200 Illustrations. Medium 8vo. 42*s.*

BIRD'S (ISABELLA) Hawaiian Archipelago; or Six Months among the Palm Groves, Coral Reefs, and Volcanoes of the Sandwich Islands. With Illustrations. Crown 8vo. 7*s.* 6*d.*

BISSET (GENERAL). Sport and War in South Africa from 1834 to 1867, with a Narrative of the Duke of Edinburgh's Visit. With Map and Illustrations. Crown 8vo. 14*s.*

BLACKSTONE'S COMMENTARIES; adapted to the Present State of the Law. By R. MALCOLM KERR, LL.D. *Revised Edition,* incorporating all the Recent Changes in the Law. 4 vols. 8vo. 60*s.*

BLUNT (REV. J. J.). Undesigned Coincidences in the Writings of the Old and New Testaments, an Argument of their Veracity: containing the Books of Moses, Historical and Prophetical Scriptures, and the Gospels and Acts. Post 8vo. 6*s.*

——— History of the Church in the First Three Centuries. Post 8vo. 6*s.*

——— Parish Priest; His Duties, Acquirements and Obligations. Post 8vo. 6*s.*

——— Lectures on the Right Use of the Early Fathers. 8vo. 9*s.*

——— University Sermons. Post 8vo. 6*s.*

——— Plain Sermons. 2 vols. Post 8vo. 12*s.*

BLOMFIELD'S (BISHOP) Memoir, with Selections from his Correspondence. By his Son. Portrait, post 8vo. 12*s.*

BOSWELL'S (JAMES) Life of Samuel Johnson, LL.D. Including the Tour to the Hebrides. Edited by Mr. CROKER. *Seventh Edition.* Portraits. 1 vol. Medium 8vo. 12*s.*

BRACE'S (C. L.) Manual of Ethnology; or the Races of the Old World. Post 8vo. 6*s.*

BOOK OF COMMON PRAYER. Illustrated with Coloured Borders, Initial Letters, and Woodcuts. 8vo. 18*s.*

BORROW'S (GEORGE) Bible in Spain; or the Journeys, Adventures, and Imprisonments of an Englishman in an Attempt to circulate the Scriptures in the Peninsula. Post 8vo. 5*s.*

——— Gypsies of Spain; their Manners, Customs, Religion, and Language. With Portrait. Post 8vo. 5*s.*

——— Lavengro; The Scholar—The Gypsy—and the Priest. Post 8vo. 5*s.*

——— Romany Rye—a Sequel to "Lavengro." Post 8vo. 5*s.*

——— WILD WALES: its People, Language, and Scenery. Post 8vo. 5*s.*

——— Romano Lavo-Lil; Word-Book of the Romany, or English Gypsy Language; with Specimens of their Poetry, and an account of certain Gypsyries. Post 8vo. 10*s.* 6*d.*

BRAY'S (MRS.) Life of Thomas Stothard, R.A. With Portrait and 60 Woodcuts. 4to. 21*s.*

——— Revolt of the Protestants in the Cevennes. With some Account of the Huguenots in the Seventeenth Century. Post 8vo. 10*s.* 6*d.*

BRITISH ASSOCIATION REPORTS. 8vo.

York and Oxford, 1831-32, 13*s.* 6*d.*
Cambridge, 1833, 12*s.*
Edinburgh, 1834, 15*s.*
Dublin, 1835, 13*s.* 6*d.*
Bristol, 1836, 12*s.*
Liverpool, 1837, 16*s.* 6*d.*
Newcastle, 1838, 15*s.*
Birmingham, 1839, 13*s.* 6*d.*
Glasgow, 1840, 15*s.*
Plymouth, 1841, 13*s.* 6*d.*
Manchester, 1842, 10*s.* 6*d.*
Cork, 1843, 12*s.*
York, 1844, 20*s.*
Cambridge, 1845, 12*s.*
Southampton, 1846, 15*s.*
Oxford, 1847, 18*s.*
Swansea, 1848, 9*s.*
Birmingham, 1849, 10*s.*
Edinburgh, 1850, 15*s.*
Ipswich, 1851, 16*s.* 6*d.*
Belfast, 1852, 15*s.*
Hull, 1853, 10*s.* 6*d.*
Liverpool, 1854, 18*s.*
Glasgow, 1855, 15*s.*
Cheltenham, 1856, 18*s.*
Dublin, 1857, 15*s.*
Leeds, 1858, 20*s.*
Aberdeen, 1859, 15*s.*
Oxford, 1860, 25*s.*
Manchester, 1861, 15*s.*
Cambridge, 1862, 20*s.*
Newcastle, 1863, 25*s.*
Bath, 1864, 18*s.*
Birmingham, 1865, 25*s*
Nottingham, 1866, 24*s.*
Dundee, 1867, 26*s.*
Norwich, 1868, 25*s.*
Exeter, 1869, 22*s.*
Liverpool, 1870, 18*s.*
Edinburgh, 1871, 16*s.*
Brighton, 1872, 24*s.*
Bradford, 1873, 25*s.*
Belfast, 1874. 25*s.*
Bristol, 1875, 25*s.*
Glasgow, 1876.

BROUGHTON'S (LORD) Journey through Albania, Turkey in Europe and Asia, to Constantinople. Illustrations. 2 Vols. 8vo. 30*s.*

——— Visits to Italy. 2 Vols. Post 8vo. 18*s.*

BROWNLOW'S (LADY) Reminiscences of a Septuagenarian. From the year 1802 to 1815. Post 8vo. 7*s.* 6*d.*

BRUGSCH'S (PROFESSOR) History of Egypt, from the earliest period. Derived from Monuments and Inscriptions. *New Edition.* Translated by H. DANBY SEYMOUR. 2 vols. 8vo. [*In Preparation.*

BUCKLEY'S (ARABELLA B.) Short History of Natural Science, and the Progress of Discovery from the time of the Greeks to the present day, for Schools and youn Persons. Illustrations. Post 8vo. 9*s.*

BURGON (REV. J. W.). Christian Gentleman; or, Memoir of Patrick Fraser Tytler. Post 8vo. 9*s.*

——— Letters from Rome. Post 8vo. 12*s.*

BURN (COL.). Dictionary of Naval and Military Technical Terms, English and French—French and English. Crown 8vo. 15*s.*

BURROW (MONTAGU). Constitutional Progress. A Series of Lectures delivered before the University of Oxford. Post 8vo. 5*s.*

BUXTON'S (CHARLES) Memoirs of Sir Thomas Fowell Buxton, Bart. With Selections from his Correspondence. Portrait. 8vo. 16*s.* *Popular Edition.* Fcap. 8vo. 5*s.*

——— Ideas of the Day. 8vo. 5*s.*

BURCKHARDT'S (DR. JACOB) Cicerone; or Art Guide to Painting in Italy. Edited by REV. DR. A. VON ZAHN, and Translated from the German by MRS. A. CLOUGH. Post 8vo. 6*s.*

BYLES' (SIR JOHN) Foundations of Religion in the Mind and Heart of Man. Post 8vo. 6*s.*

BYRON'S (LORD) Life, Letters, and Journals. By THOMAS MOORE. *Cabinet Edition.* Plates. 6 Vols. Fcap. 8vo. 18*s.*; or One Volume, Portraits. Royal 8vo., 7*s.* 6*d.*

——— and Poetical Works. *Popular Edition.* Portraits. 2 vols. Royal 8vo. 15*s.*

——— Poetical Works. *Library Edition.* Portrait. 6 Vols. 8vo. 45*s.*

——— *Cabinet Edition.* Plates. 10 Vols. 12mo. 30*s.*

——— *Pocket Edition.* 8 Vols. 24mo. 21*s.* *In a case.*

——— *Popular Edition.* Plates. Royal 8vo. 7*s.* 6*d.*

——— *Pearl Edition.* Crown 8vo. 2*s.* 6*d.*

——— Childe Harold. With 80 Engravings. Crown 8vo. 12*s.*

——— 16mo. 2*s.* 6*d.*

——— Vignettes. 16mo. 1*s.*

——— Portrait. 16mo. 6*d.*

——— Tales and Poems. 24mo. 2*s.* 6*d.*

——— Miscellaneous. 2 Vols. 24mo. 5*s.*

——— Dramas and Plays. 2 Vols. 24mo. 5*s.*

——— Don Juan and Beppo. 2 Vols. 24mo. 5*s.*

——— Beauties. Poetry and Prose. Portrait. Fcap. 8vo. 3*s.* 6*d.*

BUTTMAN'S Lexilogus; a Critical Examination of the Meaning of numerous Greek Words, chiefly in Homer and Hesiod. By Rev. J. R. FISHLAKE. 8vo. 12*s.*

——— Irregular Greek Verbs. With all the Tenses extant—their Formation, Meaning, and Usage, with Notes, by Rev. J. R. FISHLAKE. Post 8vo. 6*s.*

CALLCOTT (LADY). Little Arthur's History of England. *New Edition, brought down to* 1872. With Woodcuts. Fcap. 8vo. 1*s.* 6*d.*

CARNARVON (LORD). Portugal, Gallicia, and the Basque Provinces. Post 8vo. 3*s.* 6*d.*

CARTWRIGHT (W. C.). The Jesuits: their Constitution and Teaching. An Historical Sketch. 8vo. 9*s.*

CASTLEREAGH (THE) DESPATCHES, from the commencement of the official career of Viscount Castlereagh to the close of his life. 12 Vols. 8vo. 14*s.* each.

CAMPBELL'S (LORD) Lord Chancellors and Keepers of the Great Seal of England. From the Earliest Times to the Death of Lord Eldon in 1838. 10 Vols. Crown 8vo. 6*s.* each.

——— Chief Justices of England. From the Norman Conquest to the Death of Lord Tenterden. 4 Vols. Crown 8vo. 6*s.* each.

——— Lives of Lyndhurst and Brougham. 8vo. 16*s.*

——— Shakspeare's Legal Acquirements. 8vo. 5*s.* 6*d.*

——— Lord Bacon. Fcap. 8vo. 2*s.* 6*d.*

——— (SIR NEIL) Account of Napoleon at Fontainebleau and Elba. Being a Journal of Occurrences and Notes of his Conversations, &c. Portrait. 8vo. 15*s.*

——— (SIR GEORGE) India as it may be: an Outline of a proposed Government and Policy. 8vo. 12*s.*

——— Handy-Book on the Eastern Question; being a Very Recent View of Turkey. With Map. Post 8vo. 9*s.*

——— (THOS.) Essay on English Poetry. With Short Lives of the British Poets. Post 8vo. 3*s.* 6*d.*

CAVALCASELLE AND CROWE'S History of Painting in NORTH ITALY, from the 14th to the 16th Century. With Illustrations. 2 Vols. 8vo. 42*s.*

——— Early Flemish Painters, their Lives and Works. Illustrations. Post 8vo. 10*s.* 6*d.*; or Large Paper, 8vo. 15*s.*

——— Life and Times of Titian, with some Account of his Family. With Portrait and Illustrations. 2 vols. 8vo. 42*s.*

CHILD (G. CHAPLIN, M.D.). Benedicite; or, Song of the Three Children; being Illustrations of the Power, Beneficence, and Design manifested by the Creator in his works. Post 8vo. 6*s.*

CHISHOLM (Mrs.). Perils of the Polar Seas; True Stories of Arctic Discovery and Adventure. Illustrations. Post 8vo. 6*s.*

CHURTON (ARCHDEACON). Gongora. An Historical Essay on the Age of Philip III. and IV. of Spain. With Translations. Portrait. 2 Vols. Small 8vo. 12*s.*

——— Poetical Remains, Translations and Imitations. Portrait. Post 8vo. 7*s.* 6*d.*

——— New Testament. Edited with a Plain Practical Commentary for Families and General Readers. With 100 Panoramic and other Views, from Sketches made on the Spot. 2 vols. 8vo. 21*s.*

CICERO'S LIFE AND TIMES. His Character as a Statesman, Orator, and Friend, with a Selection from his Correspondence and Orations. By WILLIAM FORSYTH. With Illustrations. 8vo. 10*s.* 6*d.*

CLARK (SIR JAMES). Memoir of Dr. John Conolly. Comprising a Sketch of the Treatment of the Insane in Europe and America. With Portrait. Post 8vo. 10*s.* 6*d.*

CLIVE'S (LORD) Life. By REV. G. R. GLEIG. Post 8vo. 3*s.* 6*d.*

CLODE (C. M.). Military Forces of the Crown; their Administration and Government. 2 Vols. 8vo. 21*s.* each.

——— Administration of Justice under Military and Martial Law, as applicable to the Army, Navy, Marine, and Auxiliary Forces. 8vo. 12*s.*

COLCHESTER (THE) Papers. The Diary and Correspondence of Charles Abbott, Lord Colchester, Speaker of the House of Commons. 1802–1817. Portrait. 3 Vols. 8vo. 42*s.*

CHURCH (THE) & THE AGE. Essays on the Principles and Present Position of the Anglican Church. By various Authors. 2 vols. 8vo. 26*s.*

COLERIDGE'S (SAMUEL TAYLOR) Table-Talk. Portrait. 12mo. 3*s.* 6*d.*

COLLINGWOOD'S (CUTHBERT) Rambles of a Naturalist on the Shores and Waters of the China Sea. With Illustrations. 8vo. 16*s.*

COLONIAL LIBRARY. [See Home and Colonial Library.]

COMPANIONS FOR THE DEVOUT LIFE. Lectures delivered in St. James's Church. 1st Series, 1875. 2nd Series, 1876. 2 vols. 8vo. 7*s.* 6*d.* each.

COOK'S (Canon) Sermons Preached at Lincoln's Inn. 8vo. 9*s.*

COOKE'S (E. W.) Leaves from my Sketch-Book. Being a selection from sketches made during many tours. 25 Plates. Small folio. 31*s.* 6*d.*

COOKERY (MODERN DOMESTIC). Founded on Principles of Economy and Practical Knowledge. By a Lady. Woodcuts. Fcap. 8vo. 5*s.*

COOPER'S (T. T.) Travels of a Pioneer of Commerce on an Overland Journey from China towards India. Illustrations. 8vo. 16*s.*

CORNWALLIS (THE) Papers and Correspondence during the American War,—Administrations in India,—Union with Ireland, and Peace of Amiens. 3 Vols. 8vo. 63*s.*

COWPER'S (COUNTESS) Diary while Lady of the Bedchamber to Caroline, Princess of Wales, 1714—20. Portrait. 8vo. 10*s.* 6*d.*

CRABBE (REV. GEORGE). Life and Poetical Works. With Illustrations. Royal 8vo. 7*s.*

CRAWFORD & BALCARRES (Earl of). Etruscan Inscriptions. Analyzed, Translated, and Commented upon. 8vo. 12*s.*

——— Argo; or the Quest of the Golden Fleece. A Metrical Tale, in Ten Books. 8vo. 10*s.* 6*d.*

CROKER (J. W.). Progressive Geography for Children. 18mo. 1*s.* 6*d.*

——— Stories for Children, Selected from the History of England. Woodcuts. 16mo. 2*s.* 6*d.*

——— Boswell's Life of Johnson. Including the Tour to the Hebrides. *Seventh Edition.* Portraits. 8vo. 12*s.*

——— Early Period of the French Revolution. 8vo. 15*s.*

——— Historical Essay on the Guillotine. Fcap. 8vo. 1*s.*

CUMMING (R. GORDON). Five Years of a Hunter's Life in the Far Interior of South Africa. Woodcuts. Post 8vo. 6*s.*

CROWE AND CAVALCASELLE. Lives of the Early Flemish Painters. Woodcuts. Post 8vo, 10*s.* 6*d.*; or Large Paper, 8vo, 15*s.*

——— History of Painting in North Italy, from 14th to 16th Century. Derived from Researches into the Works of Art in that Country. With Illustrations. 2 Vols. 8vo. 42*s.*

——— Life and Times of Titian, with some Account of his Family, chiefly from new and unpublished records. With Portrait and Illustrations. 2 vols. 8vo. 42*s.*

CURTIUS' (PROFESSOR) Student's Greek Grammar, for the Upper Forms. Edited by DR. WM. SMITH. Post 8vo. 6*s.*

——— Elucidations of the above Grammar. Translated by EVELYN ABBOT. Post 8vo. 7*s.* 6*d.*

——— Smaller Greek Grammar for the Middle and Lower Forms. Abridged from the larger work. 12mo. 3*s.* 6*d.*

——— Accidence of the Greek Language. Extracted from the above work. 12mo. 2*s.* 6*d.*

——— Principles of Greek Etymology. Translated by A. S. WILKINS, M.A., and E. B. ENGLAND, B.A. 2 vols. 8vo. 15*s.* each.

CUNYNGHAME (SIR ARTHUR). Travels in the Eastern Caucasus, on the Caspian and Black Seas, in Daghestan and the Frontiers of Persia and Turkey. With Map and Illustrations. 8vo. 18*s.*

CURZON (HON. ROBERT). Visits to the Monasteries of the Levant. Illustrations. Post 8vo. 7*s.* 6*d.*

CUST (GENERAL). Warriors of the 17th Century—The Thirty Years' War. 2 Vols. 16*s.* Civil Wars of France and England. 2 Vols. 16*s.* Commanders of Fleets and Armies. 2 Vols. 18*s.*

——— Annals of the Wars—18th & 19th Century, 1700—1815. With Maps. 9 Vols. Post 8vo. 5*s.* each.

DAVIS (NATHAN). Ruined Cities of Numidia and Carthaginia. Illustrations. 8vo. 16*s.*

DAVY (SIR HUMPHRY). Consolations in Travel; or, Last Days of a Philosopher. Woodcuts. Fcap. 8vo. 3*s.* 6*d.*

——— Salmonia; or, Days of Fly Fishing. Woodcuts. Fcap. 8vo. 3*s.* 6*d.*

DARWIN (CHARLES). Journal of a Naturalist during a Voyage round the World. Crown 8vo. 9*s.*

——— Origin of Species by Means of Natural Selection; or, the Preservation of Favoured Races in the Struggle for Life. Crown 8vo. 7*s.* 6*d.*

——— Variation of Animals and Plants under Domestication. With Illustrations. 2 Vols. Crown 8vo. 18*s.*

——— Descent of Man, and Selection in Relation to Sex. With Illustrations. Crown 8vo. 9*s.*

——— Expressions of the Emotions in Man and Animals. With Illustrations. Crown 8vo. 12*s.*

——— Various Contrivances by which Orchids are Fertilized by Insects. Woodcuts. Crown 8vo. 9*s.*

——— Movements and Habits of Climbing Plants. Woodcuts. Crown 8vo. 6*s.*

——— Insectivorous Plants. Woodcuts. Crown 8vo. 14*s.*

——— Effects of Cross and Self-Fertilization in the Vegetable Kingdom. Crown 8vo. 12*s.*

——— Facts and Argument for Darwin. By FRITZ MULLER. Translated by W. S. DALLAS. Woodcuts. Post 8vo. 6*s.*

DE COSSON (E. A.). The Cradle of the Blue Nile; a Journey through Abyssinia and Soudan, and a residence at the Court of King John of Ethiopia. Map and Illustrations. 2 vols. Post 8vo. [*In the Press.*

DELEPIERRE (OCTAVE). History of Flemish Literature. 8vo. 9*s.*

——— Historic Difficulties & Contested Events. Post 8vo. 6*s.*

DENNIS (GEORGE). The Cities and Cemeteries of Etruria. An entirely new Edition, with a new Chapter on Etrurian Bologna. Numerous Illustrations. 2 vols. 8vo. [*In the Press.*

DERBY (EARL OF). Iliad of Homer rendered into English Blank Verse. 10*th Edition.* With Portrait. 2 Vols. Post 8vo. 10*s.*

DE ROS (LORD). Young Officer's Companion; or, Essays on Military Duties and Qualities: with Examples and Illustrations from History. Post 8vo. 9*s.*

DERRY (BP. OF). Witness of the Psalms to Christ and Christianity. The Bampton Lectures for 1876. 8vo.

DEUTSCH (EMANUEL). Talmud, Islam, The Targums and other Literary Remains. 8vo. 12*s.*

DILKE (SIR C. W.). Papers of a Critic. Selected from the Writings of the late CHAS. WENTWORTH DILKE. With a Biographical Sketch. 2 Vols. 8vo. 24*s.*

DOG-BREAKING, with Odds and Ends for those who love the Dog and Gun. By GEN. HUTCHINSON. With 40 Illustrations. Crown 8vo. 7*s.* 6*d.*

DOMESTIC MODERN COOKERY. Founded on Principles of Economy and Practical Knowledge, and adapted for Private Families. Woodcuts. Fcap. 8vo. 5*s.*

DOUGLAS'S (SIR HOWARD) Life and Adventures. Portrait. 8vo. 15*s.*

——— Theory and Practice of Gunnery. Plates. 8vo. 21*s.*

——— Construction of Bridges and the Passage of Rivers, in Military Operations. Plates. 8vo. 21*s.*

——— (WM.) Horse-Shoeing; As it Is, and As it Should be. Illustrations. Post 8vo. 7*s.* 6*d.*

DRAKE'S (SIR FRANCIS) Life, Voyages, and Exploits, by Sea and Land. By JOHN BARROW. Post 8vo. 2*s.*

DRINKWATER'S (JOHN) History of the Siege of Gibraltar, 1779-1783. With a Description and Account of that Garrison from the Earliest Periods. Post 8vo. 2*s.*

DUCANGE'S MEDIÆVAL LATIN-ENGLISH DICTIONARY. Translated by Rev. E. A. DAYMAN and J. H. HESSELS. Small 4to. [*In preparation.*

DU CHAILLU (PAUL B.). EQUATORIAL AFRICA, with Accounts of the Gorilla, the Nest-building Ape, Chimpanzee, Crocodile, &c. Illustrations. 8vo. 21*s.*

——— Journey to Ashango Land; and Further Penetration into Equatorial Africa. Illustrations. 8vo. 21*s.*

DUFFERIN'S (LORD) Letters from High Latitudes; a Yacht Voyage to Iceland, Jan Mayen, and Spitzbergen. Woodcuts. Post 8vo. 7*s.* 6*d.*

DUNCAN (MAJOR). History of the Royal Artillery. Compiled from the Original Records. With Portraits. 2 Vols. 8vo. 30*s.*

EASTLAKE'S (SIR CHARLES) Contributions to the Literature of the Fine Arts. With Memoir of the Author, and Selections from his Correspondence. By LADY EASTLAKE. 2 Vols. 8vo. 24*s.*

EDWARDS' (W. H.) Voyage up the River Amazons, including a Visit to Para. Post 8vo. 2*s.*

EIGHT MONTHS AT ROME, during the Vatican Council, with a Daily Account of the Proceedings. By POMPONIO LETO. Translated from the Original. 8vo. 12*s.*

ELDON'S (LORD) Public and Private Life, with Selections from his Correspondence and Diaries. By HORACE TWISS. Portrait. 2 Vols. Post 8vo. 21*s.*

ELGIN'S (LORD) Letters and Journals. Edited by THEODORE WALROND. With Preface by Dean Stanley. 8vo. 14*s.*

ELLESMERE (LORD). Two Sieges of Vienna by the Turks. Translated from the German. Post 8vo. 2*s.*

ELLIS (W.). Madagascar Revisited. Setting forth the Persecutions and Heroic Sufferings of the Native Christians. Illustrations. 8vo. 16*s.*

——— Memoir. By HIS SON. With his Character and Work. By REV. HENRY ALLON, D.D. Portrait. 8vo. 10*s.* 6*d.*

——— (ROBINSON) Poems and Fragments of Catullus. 16mo. 5*s.*

ELPHINSTONE (Hon. Mountstuart). History of India—the Hindoo and Mahomedan Periods. Edited by Professor Cowell. Map. 8vo. 18*s.*

———— (H. W.) Patterns for Turning; Comprising Elliptical and other Figures cut on the Lathe without the use of any Ornamental Chuck. With 70 Illustrations. Small 4to. 15*s.*

ENGLAND. See Callcott, Croker, Hume, Markham, Smith, and Stanhope.

ESSAYS ON CATHEDRALS. With an Introduction. By Dean Howson. 8vo. 12*s.*

CONTENTS.

Recollections of a Dean.—Bishop of Carlisle.
Canons and their Work. — Canon Norris.
Cathedrals in Ireland. — Dean of Cashel.
Cathedrals in their Missionary Aspect. —A. J. B. Beresford Hope.
Cathedral Foundations.—Canon Westcott.
The Old Foundation.—Edward A. Freeman.
Welsh Cathedrals.—Canon Perowne.
Choristers.—Sir F. Gore Ouseley.
Schools.—Canon Durham.
Reform.—Chancellor Massingberd.
The Chapter—Chancellor Benson.
Architecture.—Canon Venables.

ELZE (Karl). Life of Lord Byron. With a Critical Essay on his Place in Literature. Translated from the German. With Portrait. 8vo. 16*s.*

FERGUSSON (James). History of Architecture in all Countries from the Earliest Times. With 1,600 Illustrations. 4 Vols. Medium 8vo.

Vol. I. & II. Ancient and Mediæval. 63*s.*

Vol. III. Indian and Eastern, 42*s.*

Vol. IV. Modern, 31*s.* 6*d.*

———— Rude Stone Monuments in all Countries; their Age and Uses. With 230 Illustrations. Medium 8vo. 24*s.*

———— Holy Sepulchre and the Temple at Jerusalem. Woodcuts. 8vo. 7*s.* 6*d.*

FLEMING (Professor). Student's Manual of Moral Philosophy. With Quotations and References. Post 8vo. 7*s.* 6*d.*

FLOWER GARDEN. By Rev. Thos. James. Fcap. 8vo. 1*s.*

FORD (Richard). Gatherings from Spain. Post 8vo. 3*s.* 6*d.*

FORSYTH (William). Life and Times of Cicero. With Selections from his Correspondence and Orations. Illustrations. 8vo. 10*s.* 6*d.*

———— Hortensius; an Historical Essay on the Office and Duties of an Advocate. Illustrations. 8vo. 12*s.*

———— History of Ancient Manuscripts. Post 8vo. 2*s.* 6*d.*

———— Novels and Novelists of the 18th Century, in Illustration of the Manners and Morals of the Age. Post 8vo. 10*s.* 6*d.*

———— The Slavonic Provinces South of the Danube; a Sketch of their History and Present State. Map. Post 8vo. 5*s.*

FORTUNE (Robert). Narrative of Two Visits to the Tea Countries of China, 1843-52. Woodcuts. 2 Vols. Post 8vo. 18*s.*

FORSTER (John). The Early Life of Jonathan Swift. 1667-1711. With Portrait. 8vo. 15*s.*

FOSS (Edward). Biographia Juridica, or Biographical Dictionary of the Judges of England, from the Conquest to the Present Time, 1066-1870. Medium 8vo. 21*s.*

FRANCE (History of). See Markham—Smith—Student's.

FRENCH (The) in Algiers; The Soldier of the Foreign Legion—and the Prisoners of Abd-el-Kadir. Translated by Lady Duff Gordon. Post 8vo. 2*s*.

FRERE (Sir Bartle). Indian Missions. Small 8vo. 2*s*. 6*d*.

—— Eastern Africa as a field for Missionary Labour. With Map. Crown 8vo. 5*s*.

—— Bengal Famine. How it will be Met and How to Prevent Future Famines in India. With Maps. Crown 8vo. 5*s*.

GALTON (Francis). Art of Travel; or, Hints on the Shifts and Contrivances available in Wild Countries. Woodcuts. Post 8vo. 7*s*. 6*d*.

GEOGRAPHICAL SOCIETY'S JOURNAL. (*Published Yearly.*)

GEORGE (Ernest). The Mosel; a Series of Twenty Etchings, with Descriptive Letterpress. Imperial 4to. 42*s*.

—— Loire and South of France; a Series of Twenty Etchings, with Descriptive Text. Folio. 42*s*.

GERMANY (History of). See Markham.

GIBBON'S (Edward) History of the Decline and Fall of the Roman Empire. Edited by Milman and Guizot. Edited, with Notes, by Dr. Wm. Smith. Maps. 8 Vols. 8vo. 60*s*.

—— (The Student's Gibbon); Being an Epitome of the above work, incorporating the Researches of Recent Commentators. By Dr. Wm. Smith. Woodcuts. Post 8vo. 7*s*. 6*d*.

GIFFARD'S (Edward) Deeds of Naval Daring; or, Anecdotes of the British Navy. Fcap. 8vo. 3*s*. 6*d*.

GLADSTONE'S (W. E.) Financial Statements of 1853, 1860, 63–65. 8vo. 12*s*.

—— Rome and the Newest Fashions in Religion. Three Tracts. 8vo. 7*s*. 6*d*.

GLEIG'S (G. R.) Campaigns of the British Army at Washington and New Orleans. Post 8vo. 2*s*.

—— Story of the Battle of Waterloo. Post 8vo. 3*s*. 6*d*.

—— Narrative of Sale's Brigade in Affghanistan. Post 8vo. 2*s*.

—— Life of Lord Clive. Post 8vo. 3*s*. 6*d*.

—— Sir Thomas Munro. Post 8vo. 3*s*. 6*d*.

GLYNNE (Sir Stephen). Notes on the Churches of Kent. With Illustrations. 8vo. [*In Preparation.*

GOLDSMITH'S (Oliver) Works. Edited with Notes by Peter Cunningham. Vignettes. 4 Vols. 8vo. 30*s*.

GORDON'S (Sir Alex.) Sketches of German Life, and Scenes from the War of Liberation. Post 8vo. 3*s*. 6*d*.

—— (Lady Duff) Amber-Witch: A Trial for Witchcraft. Post 8vo. 2*s*.

—— French in Algiers. 1. The Soldier of the Foreign Legion. 2. The Prisoners of Abd-el-Kadir. Post 8vo. 2*s*.

GRAMMARS. See Curtius; Hall; Hutton; King Edward; Matthiæ; Maetzner; Smith.

GREECE (History of). *See* Grote—Smith—Student.

GREY'S (Earl) Correspondence with King William IVth and Sir Herbert Taylor, from 1830 to 1832. 2 Vols. 8vo. 30*s.*

——— Parliamentary Government and Reform; with Suggestions for the Improvement of our Representative System. *Second Edition.* 8vo. 9*s.*

GUIZOT'S (M.) Meditations on Christianity. 3 Vols. Post 8vo. 30*s.*

GROTE (George). History of Greece. From the Earliest Times to the close of the generation contemporary with the death of Alexander the Great. *Library Edition.* Portrait, Maps, and Plans. 10 Vols. 8vo. 120*s.* *Cabinet Edition.* Portrait and Plans. 12 Vols. Post 8vo. 6*s.* each.

——— Plato, and other Companions of Socrates. 3 Vols. 8vo. 45*s.*

——— Aristotle. 2 Vols. 8vo. 32*s.*

——— Minor Works. With Critical Remarks on his Intellectual Character, Writings, and Speeches. By Alex. Bain, LL.D. Portrait. 8vo. 14*s.*

——— Fragments on Ethical Subjects. Being a Selection from his Posthumous Papers. With an Introduction. By Alexander Bain, M.A. 8vo. 7*s.*

——— Letters on the Politics of Switzerland in 1847. 6*s.*

——— Personal Life. Compiled from Family Documents, Private Memoranda, and Original Letters to and from Various Friends. By Mrs. Grote. Portrait. 8vo. 12*s.*

HALL (T. D.) and Dr. Wm. SMITH'S School Manual of English Grammar. With Copious Exercises. 12mo. 3*s.* 6*d.*

——— Primary English Grammar for Elementary Schools. Based on the above work. 16mo. 1*s.*

——— Child's First Latin Book, including a Systematic Treatment of the New Pronunciation, and a full Praxis of Nouns, Adjectives, and Pronouns. 16mo. 1*s.* 6*d.*

HALLAM'S (Henry) Constitutional History of England, from the Accession of Henry the Seventh to the Death of George the Second. *Library Edition.* 3 Vols. 8vo. 30*s.* *Cabinet Edition,* 3 Vols. Post 8vo. 12*s.*

——— Student's Edition of the above work. Edited by Wm. Smith, D.C.L. Post 8vo. 7*s.* 6*d.*

——— History of Europe during the Middle Ages. *Library Edition.* 3 Vols. 8vo. 30*s.* *Cabinet Edition,* 3 Vols. Post 8vo. 12*s.*

——— Student's Edition of the above work. Edited by Wm. Smith, D.C.L. Post 8vo. 7*s.* 6*d.*

——— Literary History of Europe, during the 15th, 16th and 17th Centuries. *Library Edition.* 3 Vols. 8vo. 36*s.* *Cabinet Edition.* 4 Vols. Post 8vo. 16*s.*

——— (Arthur) Literary Remains; in Verse and Prose. Portrait. Fcap. 8vo. 3*s.* 6*d.*

HAMILTON'S (Gen. Sir F. W.) History of the Grenadier Guards. From Original Documents in the Rolls' Records, War Office, Regimental Records, &c. With Illustrations. 3 Vols. 8vo. 63*s.*

HART'S ARMY LIST. (*Published Quarterly and Annually.*)

HAY'S (Sir J. H. Drummond) Western Barbary, its Wild Tribes and Savage Animals. Post 8vo. 2*s.*

HEAD'S (SIR FRANCIS) Royal Engineer. Illustrations. 8vo. 12*s.*

——— Life of Sir John Burgoyne. Post 8vo. 1*s.*

——— Rapid Journeys across the Pampas. Post 8vo. 2*s.*

——— Bubbles from the Brunnen of Nassau. Illustrations. Post 8vo. 7*s.* 6*d.*

——— Stokers and Pokers; or, the London and North Western Railway. Post 8vo. 2*s.*

——— (SIR EDMUND) Shall and Will; or, Future Auxiliary Verbs. Fcap. 8vo. 4*s.*

HEBER'S (BISHOP) Journals in India. 2 Vols. Post 8vo. 7*s.*

——— Poetical Works. Portrait. Fcap. 8vo. 3*s.* 6*d.*

——— Hymns adapted to the Church Service. 16mo. 1*s.* 6*d.*

HERODOTUS. A New English Version. Edited, with Notes and Essays, historical, ethnographical, and geographical, by CANON RAWLINSON, assisted by SIR HENRY RAWLINSON and SIR J. G. WILKINSON. Maps and Woodcuts. 4 Vols. 8vo. 48*s.*

HERSCHEL'S (CAROLINE) Memoir and Correspondence. By MRS. JOHN HERSCHEL. With Portraits. Crown 8vo 12*s.*

HATHERLEY'S (LORD) Continuity of Scripture, as Declared by the Testimony of our Lord and of the Evangelists and Apostles. 8vo. 6*s.* *Popular Edition.* Post 8vo. 2*s.* 6*d.*

HOLLWAY'S (J. G.) Month in Norway. Fcap. 8vo. 2*s.*

HONEY BEE. By REV. THOMAS JAMES. Fcap. 8vo. 1*s.*

HOOK'S (DEAN) Church Dictionary. 8vo. 16*s.*

——— (THEODORE) Life. By J. G. LOCKHART. Fcap. 8vo. 1*s.*

HOPE (T. C.). ARCHITECTURE OF AHMEDABAD, with Historical Sketch and Architectural Notes. With Maps, Photographs, and Woodcuts. 4to. 5*l.* 5*s.*

——— (A. J. BERESFORD) Worship in the Church of England. 8vo. 9*s.*, or, *Popular Selections from.* 8vo. 2*s.* 6*d.*

HORACE; a New Edition of the Text. Edited by DEAN MILMAN. With 100 Woodcuts. Crown 8vo. 7*s.* 6*d.*

——— Life of. By DEAN MILMAN. Illustrations. 8vo. 9*s.*

HOUGHTON'S (LORD) Monographs, Personal and Social. With Portraits. Crown 8vo. 10*s.* 6*d.*

——— POETICAL WORKS. *Collected Edition.* With Portrait. 2 Vols. Fcap. 8vo. 12*s.*

HUME'S (The Student's) History of England, from the Invasion of Julius Cæsar to the Revolution of 1688. Corrected and continued to 1868. Woodcuts. Post 8vo. 7*s.* 6*d.*

HUTCHINSON (GEN.) Dog Breaking, with Odds and Ends for those who love the Dog and the Gun. With 40 Illustrations. 6th edition. 7*s.* 6*d.*

HUTTON'S (H. E.) Principia Græca; an Introduction to the Study of Greek. Comprehending Grammar, Delectus, and Exercise-book, with Vocabularies. *Sixth Edition.* 12mo. 3*s.* 6*d.*

FOREIGN HANDBOOKS.

HAND-BOOK—TRAVEL-TALK. English, French, German, and Italian. 18mo. 3*s.* 6*d.*

——— HOLLAND AND BELGIUM. Map and Plans. Post 8vo. 6*s.*

——— NORTH GERMANY and THE RHINE,—The Black Forest, the Hartz, Thüringerwald, Saxon Switzerland, Rügen the Giant Mountains, Taunus, Odenwald, Elass, and Lothringen. Map and Plans. Post 8vo.

——— SOUTH GERMANY,—Wurtemburg, Bavaria, Austria, Styria, Salzburg, the Austrian and Bavarian Alps, Tyrol, Hungary, and the Danube, from Ulm to the Black Sea. Map. Post 8vo. 10*s.*

——— PAINTING. German, Flemish, and Dutch Schools. Illustrations. 2 Vols. Post 8vo. 24*s.*

——— LIVES OF EARLY FLEMISH PAINTERS. By CROWE and CAVALCASELLE. Illustrations. Post 8vo. 10*s.* 6*d.*

——— SWITZERLAND, Alps of Savoy, and Piedmont. Maps. Post 8vo. 9*s.*

——— FRANCE, Part I. Normandy, Brittany, the French Alps, the Loire, the Seine, the Garonne, and the Pyrenees. Post 8vo. 7*s.* 6*d.*

——— Part II. Central France, Auvergne, the Cevennes, Burgundy, the Rhone and Saone, Provence, Nimes, Arles, Marseilles, the French Alps, Alsace, Lorraine, Champagne, &c. Maps. Post 8vo. 7*s.* 6*d.*

——— MEDITERRANEAN ISLANDS—Malta, Corsica, Sardinia, and Sicily. Maps. Post 8vo. [*In the Press.*

——— ALGERIA. Algiers, Constantine, Oran, the Atlas Range. Map. Post 8vo. 9*s.*

——— PARIS, and its Environs. Map. 16mo. 3*s.* 6*d.*
*** MURRAY'S PLAN OF PARIS, mounted on canvas. 3*s.* 6*d.*

——— SPAIN, Madrid, The Castiles, The Basque Provinces, Leon, The Asturias, Galicia, Estremadura, Andalusia, Ronda, Granada, Murcia, Valencia, Catalonia, Aragon, Navarre, The Balearic Islands, &c. &c. Maps. 2 Vols. Post 8vo. 24*s.*

——— PORTUGAL, LISBON, Porto, Cintra, Mafra, &c. Map. Post 8vo. 12*s.*

——— NORTH ITALY, Turin, Milan, Cremona, the Italian Lakes, Bergamo, Brescia, Verona, Mantua, Vicenza, Padua, Ferrara, Bologna, Ravenna, Rimini, Piacenza, Genoa, the Riviera, Venice, Parma, Modena, and Romagna. Map. Post 8vo. 10*s.*

——— CENTRAL ITALY, Florence, Lucca, Tuscany, The Marches, Umbria, and the late Patrimony of St. Peter's. Map. Post 8vo. 10*s.*

——— ROME AND ITS ENVIRONS. Map. Post 8vo. 10*s.*

——— SOUTH ITALY, Two Sicilies, Naples, Pompeii, Herculaneum, and Vesuvius. Map. Post 8vo. 10*s.*

——— KNAPSACK GUIDE TO ITALY. 16mo.

——— PAINTING. The Italian Schools. Illustrations. 2 Vols. Post 8vo. 30*s.*

——— LIVES OF ITALIAN PAINTERS, FROM CIMABUE to BASSANO. By MRS. JAMESON. Portraits. Post 8vo. 12*s.*

——— NORWAY, Christiania, Bergen, Trondhjem. The Fjelds and Fjords. Map. Post 8vo. 9*s.*

——— SWEDEN, Stockholm, Upsala, Gothenburg, the Shores of the Baltic, &c. Post 8vo. 6*s.*

HAND-BOOK—DENMARK, Sleswig, Holstein, Copenhagen, Jutland, Iceland. Map. Post 8vo. 6*s.*

——— RUSSIA, ST. PETERSBURG, MOSCOW, POLAND, and FINLAND. Maps. Post 8vo. 18*s.*

——— GREECE, the Ionian Islands, Continental Greece, Athens, the Peloponnesus, the Islands of the Ægean Sea, Albania, Thessaly, and Macedonia. Maps. Post 8vo. 15*s.*

——— TURKEY IN ASIA—CONSTANTINOPLE, the Bosphorus, Dardanelles, Brousa, Plain of Troy, Crete, Cyprus, Smyrna, Ephesus, the Seven Churches, Coasts of the Black Sea, Armenia, Mesopotamia, &c. Maps. Post 8vo. 15*s.*

——— EGYPT, including Descriptions of the Course of the Nile through Egypt and Nubia, Alexandria, Cairo, and Thebes, the Suez Canal, the Pyramids, the Peninsula of Sinai, the Oases, the Fyoom, &c. Map. Post 8vo. 15*s*

——— HOLY LAND—SYRIA, PALESTINE, Peninsula of Sinai, Edom, Syrian Deserts, Petra, Damascus, and Palmyra. Maps. Post 8vo. *** Travelling Map of Palestine. In case. 12*s.*

——— INDIA — BOMBAY AND MADRAS. Map. 2 Vols. Post 8vo. 12*s.* each.

ENGLISH HANDBOOKS.

HAND-BOOK—MODERN LONDON. Map. 16mo. 3*s.* 6*d.*

——— ENVIRONS OF LONDON within a circuit of 20 miles. 2 Vols. Crown 8vo. 21*s.*

——— EASTERN COUNTIES, Chelmsford, Harwich, Colchester, Maldon, Cambridge, Ely, Newmarket, Bury St. Edmunds, Ipswich, Woodbridge, Felixstowe, Lowestoft, Norwich, Yarmouth, Cromer, &c. Map and Plans. Post 8vo. 12*s.*

——— CATHEDRALS of Oxford, Peterborough, Norwich, Ely, and Lincoln. With 90 Illustrations. Crown 8vo. 18*s.*

——— KENT AND SUSSEX, Canterbury, Dover, Ramsgate, Sheerness, Rochester, Chatham, Woolwich, Brighton, Chichester, Worthing, Hastings, Lewes, Arundel, &c. Map. Post 8vo.

——— SURREY AND HANTS, Kingston, Croydon, Reigate, Guildford, Dorking, Boxhill, Winchester, Southampton, New Forest, Portsmouth, and ISLE OF WIGHT. Maps. Post 8vo. 10*s.*

——— BERKS, BUCKS, AND OXON, Windsor, Eton, Reading, Aylesbury, Uxbridge, Wycombe, Henley, the City and University of Oxford, Blenheim, and the Descent of the Thames. Map. Post 8vo. 7*s.* 6*d.*

——— WILTS, DORSET, AND SOMERSET, Salisbury, Chippenham, Weymouth, Sherborne, Wells, Bath, Bristol, Taunton, &c. Map. Post 8vo. 10*s.*

——— DEVON AND CORNWALL, Exeter, Ilfracombe, Linton, Sidmouth, Dawlish, Teignmouth, Plymouth, Devonport, Torquay, Launceston, Truro, Penzance, Falmouth, the Lizard, Land's End, &c. Maps. Post 8vo. 12*s.*

——— CATHEDRALS of Winchester, Salisbury, Exeter, Wells, Chichester, Rochester, Canterbury, and St. Albans. With 130 Illustrations. 2 Vols. Crown 8vo. 36*s.*

——— GLOUCESTER, HEREFORD, AND WORCESTER, Cirencester, Cheltenham, Stroud, Tewkesbury, Leominster, Ross, Malvern, Kidderminster, Dudley, Bromsgrove, Evesham. Map. Post 8vo. 9*s.*

——— CATHEDRALS of Bristol, Gloucester, Hereford, Worcester, and Lichfield. With 50 Illustrations. Crown 8vo. 16*s.*

——— NORTH WALES, Bangor, Carnarvon, Beaumaris, Snowdon, Llanberis, Dolgelly, Cader Idris, Conway, &c. Map. Post 8vo. 7*s.*

HAND-BOOK—SOUTH WALES, Monmouth, Llandaff, Merthyr, Vale of Neath, Pembroke, Carmarthen, Tenby, Swansea, The Wye, &c. Map. Post 8vo. 7*s.*

——— CATHEDRALS OF BANGOR, ST. ASAPH, Llandaff, and St. David's. With Illustrations. Post 8vo. 15*s.*

——— DERBY, NOTTS, LEICESTER, STAFFORD, Matlock, Bakewell, Chatsworth, The Peak, Buxton, Hardwick, Dove Dale, Ashborne, Southwell, Mansfield, Retford, Burton, Belvoir, Melton Mowbray, Wolverhampton, Lichfield, Walsall, Tamworth. Map. Post 8vo. 9*s.*

——— SHROPSHIRE, CHESHIRE AND LANCASHIRE—Shrewsbury, Ludlow, Bridgnorth, Oswestry, Chester, Crewe, Alderley, Stockport, Birkenhead, Warrington, Bury, Manchester, Liverpool, Burnley, Clitheroe, Bolton, Blackburn, Wigan, Preston, Rochdale, Lancaster, Southport, Blackpool, &c. Map. Post 8vo. 10*s.*

——— YORKSHIRE, Doncaster, Hull, Selby, Beverley, Scarborough, Whitby, Harrogate, Ripon, Leeds, Wakefield, Bradford, Halifax, Huddersfield, Sheffield. Map and Plans. Post 8vo. 12*s.*

——— CATHEDRALS of York, Ripon, Durham, Carlisle, Chester, and Manchester. With 60 Illustrations. 2 Vols. Crown 8vo. 21*s.*

——— DURHAM AND NORTHUMBERLAND, Newcastle, Darlington, Gateshead, Bishop Auckland, Stockton, Hartlepool, Sunderland, Shields, Berwick-on-Tweed, Morpeth, Tynemouth, Coldstream, Alnwick, &c. Map. Post 8vo. 9*s.*

——— WESTMORLAND AND CUMBERLAND—Lancaster, Furness Abbey, Ambleside, Kendal, Windermere, Coniston, Keswick, Grasmere, Ulswater, Carlisle, Cockermouth, Penrith, Appleby. Map. Post 8vo. 6*s.*

*** MURRAY'S MAP OF THE LAKE DISTRICT, on canvas. 3*s.* 6*d.*

——— ENGLAND AND WALES. Alphabetically arranged and condensed into one volume. Post 8vo. [*In the Press.*

——— SCOTLAND, Edinburgh, Melrose, Kelso, Glasgow, Dumfries, Ayr, Stirling, Arran, The Clyde, Oban, Inverary, Loch Lomond, Loch Katrine and Trossachs, Caledonian Canal, Inverness, Perth, Dundee, Aberdeen, Braemar, Skye, Caithness, Ross, Sutherland, &c. Maps and Plans. Post 8vo. 9*s.*

——— IRELAND, Dublin, Belfast, Donegal, Galway, Wexford, Cork, Limerick, Waterford, Killarney, Munster, &c. Maps. Post 8vo. 12*s.*

IRBY AND MANGLES' Travels in Egypt, Nubia, Syria, and the Holy Land. Post 8vo. 2*s.*

JACOBSON'S (BISHOP) Fragmentary Illustrations of the History of the Book of Common Prayer; from Manuscript Sources (Bishop SANDERSON and Bishop WREN). 8vo. 5*s.*

JAMES' (REV. THOMAS) Fables of Æsop. A New Translation, with Historical Preface. With 100 Woodcuts by TENNIEL and WOLF. Post 8vo. 2*s.* 6*d.*

JAMESON (MRS.). Lives of the Early Italian Painters—and the Progress of Painting in Italy—Cimabue to Bassano. With 50 Portraits' Post 8vo. 12*s.*

JERVIS (REV. W. H.). Gallican Church, from the Concordat of Bologna, 1516, to the Revolution. With an Introduction. Portraits. 2 Vols. 8vo. 28*s.*

JESSE'S (EDWARD) Gleanings in Natural History. Fcp. 8vo. 3*s.* 6*d.*

JEX-BLAKE (REV. T. W.). Life in Faith: Sermons Preached at Cheltenham and Rugby. Fcap. 8vo. 3*s.* 6*d.*

JOHNS' (REV. B. G.) Blind People; their Works and Ways. With Sketches of the Lives of some famous Blind Men. With Illustrations. Post 8vo. 7*s.* 6*d.*

HOME AND COLONIAL LIBRARY. A Series of Works adapted for all circles and classes of Readers, having been selected for their acknowledged interest, and ability of the Authors. Post 8vo. Published at 2*s.* and 3*s.* 6*d.* each, and arranged under two distinctive heads as follows :—

CLASS A.

HISTORY, BIOGRAPHY, AND HISTORIC TALES.

1. SIEGE OF GIBRALTAR. By JOHN DRINKWATER. 2*s.*
2. THE AMBER-WITCH. By LADY DUFF GORDON. 2*s.*
3. CROMWELL AND BUNYAN. By ROBERT SOUTHEY. 2*s.*
4. LIFE OF SIR FRANCIS DRAKE. By JOHN BARROW. 2*s.*
5. CAMPAIGNS AT WASHINGTON. By REV. G. R. GLEIG. 2*s.*
6. THE FRENCH IN ALGIERS. By LADY DUFF GORDON. 2*s.*
7. THE FALL OF THE JESUITS. 2*s.*
8. LIVONIAN TALES. 2*s.*
9. LIFE OF CONDÉ. By LORD MAHON. 3*s.* 6*d.*
10. SALE'S BRIGADE. By REV. G. R. GLEIG. 2*s*
11. THE SIEGES OF VIENNA. By LORD ELLESMERE. 2*s.*
12. THE WAYSIDE CROSS. By CAPT. MILMAN. 2*s.*
13. SKETCHES OF GERMAN LIFE. By SIR A. GORDON. 3*s.* 6*d.*
14. THE BATTLE OF WATERLOO. By REV. G. R. GLEIG. 3*s.* 6*d.*
15. AUTOBIOGRAPHY OF STEFFENS. 2*s.*
16. THE BRITISH POETS. By THOMAS CAMPBELL. 3*s.* 6*d.*
17. HISTORICAL ESSAYS. By LORD MAHON. 3*s.* 6*d.*
18. LIFE OF LORD CLIVE. By REV. G. R. GLEIG. 3*s.* 6*d.*
19. NORTH - WESTERN RAILWAY. By SIR F. B. HEAD. 2*s.*
20. LIFE OF MUNRO. By REV. G. R. GLEIG. 3*s.* 6*d.*

CLASS B.

VOYAGES, TRAVELS, AND ADVENTURES.

1. BIBLE IN SPAIN. By GEORGE BORROW. 3*s.* 6*d.*
2. GYPSIES OF SPAIN. By GEORGE BORROW. 3*s.* 6*d.*

3 & 4. JOURNALS IN INDIA. By BISHOP HEBER. 2 Vols. 7*s.*

5. TRAVELS IN THE HOLY LAND. By IRBY and MANGLES. 2*s.*
6. MOROCCO AND THE MOORS. By J. DRUMMOND HAY. 2*s.*
7. LETTERS FROM THE BALTIC. By a LADY.
8. NEW SOUTH WALES. By MRS. MEREDITH. 2*s.*
9. THE WEST INDIES. By M. G. LEWIS. 2*s.*
10. SKETCHES OF PERSIA. By SIR JOHN MALCOLM. 3*s.* 6*d.*
11. MEMOIRS OF FATHER RIPA. 2*s.*

12 & 13. TYPEE AND OMOO. By HERMANN MELVILLE. 2 Vols. 7*s.*

14. MISSIONARY LIFE IN CANADA. By REV. J. ABBOTT. 2*s.*
15. LETTERS FROM MADRAS. By a LADY. 2*s.*
16. HIGHLAND SPORTS. By CHARLES ST. JOHN. 3*s.* 6*d.*
17. PAMPAS JOURNEYS. By SIR F. B. HEAD. 2*s.*
18. GATHERINGS FROM SPAIN. By RICHARD FORD. 3*s.* 6*d.*
19. THE RIVER AMAZON. By W. H. EDWARDS. 2*s.*
20. MANNERS & CUSTOMS OF INDIA. By REV. C. ACLAND. 2*s.*
21. ADVENTURES IN MEXICO. By G. F. RUXTON. 3*s.* 6*d.*
22. PORTUGAL AND GALICIA. By LORD CARNARVON. 3*s.* 6*d.*
23. BUSH LIFE IN AUSTRALIA. By REV. H. W. HAYGARTH. 2*s.*
24. THE LIBYAN DESERT. By BAYLE ST. JOHN. 2*s.*
25. SIERRA LEONE. By A LADY. 3*s.* 6*d.*

*** Each work may be had separately.

JOHNSON'S (DR. SAMUEL) Life. By James Boswell. Including the Tour to the Hebrides. Edited by MR. CROKER. *New Edition.* Portraits. 4 Vols. 8vo. [*In Preparation.*

——— Lives of the most eminent English Poets, with Critical Observations on their Works. Edited with Notes, Corrective and Explanatory, by PETER CUNNINGHAM. 3 vols. 8vo. 22*s.* 6*d.*

JUNIUS' HANDWRITING Professionally investigated. By Mr. CHABOT, Expert. With Preface and Collateral Evidence, by the Hon. EDWARD TWISLETON. With Facsimiles, Woodcuts, &c. 4to. £3 3*s.*

KEN'S (BISHOP) Life. By a LAYMAN. Portrait. 2 Vols. 8vo. 18*s.*

——— Exposition of the Apostles' Creed. 16mo. 1*s.* 6*d.*

KERR (ROBERT). GENTLEMAN'S HOUSE; OR, HOW TO PLAN ENGLISH RESIDENCES FROM THE PARSONAGE TO THE PALACE. With Views and Plans. 8vo. 24*s.*

——— Small Country House. A Brief Practical Discourse on the Planning of a Residence from 2000*l.* to 5000*l.* With Supplementary Estimates to 7000*l.* Post 8vo. 3*s.*

——— Ancient Lights; a Book for Architects, Surveyors, Lawyers, and Landlords. 8vo. 5*s.* 6*d.*

——— (R. MALCOLM) Student's Blackstone. A Systematic Abridgment of the entire Commentaries, adapted to the present state of the law. Post 8vo. 7*s.* 6*d.*

KING EDWARD VITH's Latin Grammar. 12mo. 3*s.* 6*d.*

——— First Latin Book. 12mo. 2*s* 6*d.*

KING GEORGE IIIRD's Correspondence with Lord North, 1769-82. Edited, with Notes and Introduction, by W. BODHAM DONNE. 2 vols. 8vo. 32*s.*

KING (R. J.). Archæology, Travel and Art; being Sketches and Studies, Historical and Descriptive. 8vo. 12*s.*

KIRK (J. FOSTER). History of Charles the Bold, Duke of Burgundy. Portrait. 3 Vols. 8vo. 45*s.*

KIRKES' Handbook of Physiology. Edited by W. MORRANT BAKER, F.R.C.S. 9*th Edition.* With 400 Illustrations. Post 8vo. 14*s.*

KUGLER'S Handbook of Painting.—The Italian Schools. Revised and Remodelled from the most recent Researches. By LADY EASTLAKE. With 140 Illustrations. 2 Vols. Crown 8vo. 30*s.*

——— Handbook of Painting.—The German, Flemish, and Dutch Schools. Revised and in part re-written. By J. A. CROWE. With 60 Illustrations. 2 Vols. Crown 8vo. 24*s.*

LANE (E. W.). Account of the Manners and Customs of Modern Egyptians. With Illustrations. 2 Vols. Post 8vo. 12*s*

LAWRENCE'S (SIR GEO.) Reminiscences of Forty-three Years' Service in India; including Captivities in Cabul among the Affghans and among the Sikhs, and a Narrative of the Mutiny in Rajputana. Crown 8vo. 10*s.* 6*d.*

LAYARD (A. H.). Nineveh and its Remains. Being a Narrative of Researches and Discoveries amidst the Ruins of Assyria. With an Account of the Chaldean Christians of Kurdistan; the Yezedis, or Devil-worshippers; and an Enquiry into the Manners and Arts of the Ancient Assyrians. Plates and Woodcuts. 2 Vols. 8vo. 36*s.*

*** A POPULAR EDITION of the above work. With Illustrations. Post 8vo. 7*s.* 6*d.*

——— Nineveh and Babylon; being the Narrative of Discoveries in the Ruins, with Travels in Armenia, Kurdistan and the Desert, during a Second Expedition to Assyria. With Map and Plates. 8vo. 21*s.*

*** A POPULAR EDITION of the above work. With Illustrations. Post 8vo. 7*s.* 6*d.*

LEATHES' (STANLEY) Practical Hebrew Grammar. With the Hebrew Text of Genesis i.—vi., and Psalms i.—vi. Grammatical Analysis and Vocabulary. Post 8vo. 7*s*. 6*d*.

LENNEP (REV. H. J. VAN). Missionary Travels in Asia Minor. With Illustrations of Biblical History and Archæology. With Map and Woodcuts. 2 Vols. Post 8vo. 24*s*.

——— Modern Customs and Manners of Bible Lands in Illustration of Scripture. With Coloured Maps and 300 Illustrations. 2 Vols. 8vo. 21*s*.

LESLIE (C. R.). Handbook for Young Painters. With Illustrations. Post 8vo. 7*s*. 6*d*.

——— Life and Works of Sir Joshua Reynolds. Portraits and Illustrations. 2 Vols. 8vo. 42*s*.

LETO (POMPONIO). Eight Months at Rome during the Vatican Council. With a daily account of the proceedings. Translated from the original. 8vo. 12*s*.

LETTERS FROM THE BALTIC. By a LADY. Post 8vo. 2*s*.

——— MADRAS. By a LADY. Post 8vo. 2*s*.

——— SIERRA LEONE. By a LADY. Post 8vo. 3*s*. 6*d*.

LEVI (LEONE). History of British Commerce; and of the Economic Progress of the Nation, from 1763 to 1870. 8vo. 16*s*.

LIDDELL (DEAN). Student's History of Rome, from the earliest Times to the establishment of the Empire. With Woodcuts. Post 8vo. 7*s*. 6*d*.

LLOYD (W. WATKISS). History of Sicily to the Athenian War; with Elucidations of the Sicilian Odes of Pindar. With Map. 8vo. 14*s*.

LISPINGS from LOW LATITUDES; or, the Journal of the Hon. Impulsia Gushington. Edited by LORD DUFFERIN. With 24 Plates. 4to. 21*s*.

LITTLE ARTHUR'S HISTORY OF ENGLAND. By LADY CALLCOTT. *New Edition, continued to* 1872. With Woodcuts. Fcap. 8vo. 1*s*. 6*d*.

LIVINGSTONE'S (DR.) Popular Account of his First Expedition to Africa, 1840-56. Illustrations. Post 8vo. 7*s*. 6*d*.

——— Popular Account of his Second Expedition to Africa, 1858-64. Map and Illustrations. Post 8vo. 7*s*. 6*d*.

——— Last Journals in Central Africa, from 1865 to his Death. Continued by a Narrative of his last moments and sufferings. By Rev. HORACE WALLER. Maps and Illustrations. 2 Vols. 8vo. 28*s*.

LIVONIAN TALES. By the Author of "Letters from the Baltic." Post 8vo. 2*s*.

LOCH (H. B.). Personal Narrative of Events during Lord Elgin's Second Embassy to China. With Illustrations. Post 8vo. 9*s*.

LOCKHART (J. G.). Ancient Spanish Ballads. Historical and Romantic. Translated, with Notes. With Portrait and Illustrations. Crown 8vo. 5*s*.

——— Life of Theodore Hook. Fcap. 8vo. 1*s*.

LOUDON (MRS.). Gardening for Ladies. With Directions and Calendar of Operations for Every Month. Woodcuts. Fcap. 8vo. 3*s*. 6*d*.

LUCKNOW: A Lady's Diary of the Siege. Fcap. 8vo. 4*s*. 6*d*.

LYELL (SIR CHARLES). Principles of Geology; or, the Modern Changes of the Earth and its Inhabitants considered as illustrative of Geology. With Illustrations. 2 Vols. 8vo. 32*s*.

——— Student's Elements of Geology. With Table of British Fossils and 600 Illustrations. Post 8vo. 9*s*.

——— Geological Evidences of the Antiquity of Man, including an Outline of Glacial Post-Tertiary Geology, and Remarks on the Origin of Species. Illustrations. 8vo. 14*s*.

LYELL (K. M.). Geographical Handbook of Ferns. With Tables to show their Distribution. Post 8vo. 7*s.* 6*d.*

LYTTON'S (LORD) Memoir of Julian Fane. With Portrait. Post 8vo. 5*s.*

McCLINTOCK (SIR L.). Narrative of the Discovery of the Fate of Sir John Franklin and his Companions in the Arctic Seas. With Illustrations. Post 8vo. 7*s.* 6*d.*

MACDOUGALL (COL.). Modern Warfare as Influenced by Modern Artillery. With Plans. Post 8vo. 12*s.*

MACGREGOR (J.). Rob Roy on the Jordan, Nile, Red Sea, Gennesareth, &c. A Canoe Cruise in Palestine and Egypt and the Waters of Damascus. With Map and 70 Illustrations. Crown 8vo. 7*s.* 6*d.*

MAETZNER'S ENGLISH GRAMMAR. A Methodical, Analytical, and Historical Treatise on the Orthography, Prosody, Inflections, and Syntax of the English Tongue. Translated from the German. By CLAIR J. GRECE, LL.D. 3 Vols. 8vo. 36*s.*

MAHON (LORD), see STANHOPE.

MAINE (SIR H. SUMNER). Ancient Law: its Connection with the Early History of Society, and its Relation to Modern Ideas. 8vo. 12*s.*

——— Village Communities in the East and West. With additional Essays. 8vo. 12*s.*

——— Early History of Institutions. 8vo. 12*s.*

MALCOLM'S (SIR JOHN) Sketches of Persia. Post 8vo. 3*s.* 6*d.*

MANSEL (DEAN). Limits of Religious Thought Examined. Post 8vo. 8*s.* 6*d.*

——— Letters, Lectures, and Papers, including the Phrontisterion, or Oxford in the XIXth Century. Edited by H. W. CHANDLER, M.A. 8vo. 12*s.*

——— Gnostic Heresies of the First and Second Centuries. With a sketch of his life and character. By Lord CARNARVON. Edited by Canon LIGHTFOOT. 8vo. 10*s.* 6*d.*

MANUAL OF SCIENTIFIC ENQUIRY. For the Use of Travellers. Edited by REV. R. MAIN. Post 8vo. 3*s.* 6*d.* (*Published by order of the Lords of the Admiralty.*)

MARCO POLO. The Book of Ser Marco Polo, the Venetian. Concerning the Kingdoms and Marvels of the East. A new English Version. Illustrated by the light of Oriental Writers and Modern Travels. By COL. HENRY YULE. Maps and Illustrations. 2 Vols. Medium 8vo. 63*s.*

MARKHAM'S (MRS.) History of England. From the First Invasion by the Romans *to* 1867. Woodcuts. 12mo. 3*s.* 6*d.*

——— History of France. From the Conquest by the Gauls *to* 1861. Woodcuts. 12mo. 3*s.* 6*d.*

——— History of Germany. From the Invasion by Marius *to* 1867. Woodcuts. 12mo. 3*s.* 6*d.*

MARLBOROUGH'S (SARAH, DUCHESS OF) Letters. Now first published from the Original MSS. at Madresfield Court. With an Introduction. 8vo. 10*s.* 6*d.*

MARRYAT (JOSEPH). History of Modern and Mediæval Pottery and Porcelain. With a Description of the Manufacture. Plates and Woodcuts. 8vo. 42*s.*

MARSH (G. P.). Student's Manual of the English Language. Post 8vo. 7*s.* 6*d.*

MATTHIÆ'S GREEK GRAMMAR. Abridged by BLOMFIELD, *Revised* by E. S. CROOKE. 12mo. 4*s.*

MAUREL'S Character, Actions, and Writings of Wellington. Fcap. 8vo. 1*s.* 6*d.*

MAYNE (CAPT.). Four Years in British Columbia and Vancouver Island. Illustrations. 8vo. 16*s.*

MAYO (LORD). Sport in Abyssinia; or, the Mareb and Tackazzee. With Illustrations. Crown 8vo. 12*s.*

MEADE (HON. HERBERT). Ride through the Disturbed Districts of New Zealand, with a Cruise among the South Sea Islands. With Illustrations. Medium 8vo. 12*s.*

MELVILLE (HERMANN). Marquesas and South Sea Islands. 2 Vols. Post 8vo. 7*s.*

MEREDITH'S (MRS. CHARLES) Notes and Sketches of New South Wales. Post 8vo. 2*s.*

MESSIAH (THE): The Life, Travels, Death, Resurrection, and Ascension of our Blessed Lord. By A Layman. Map. 8vo. 18*s.*

MICHELANGELO - BUONARROTI, Sculptor, Painter, and Architect. His Life and Works. By C. HEATH WILSON. Illustrations. Royal 8vo. 26*s.*

MILLINGTON (REV. T. S.). Signs and Wonders in the Land of Ham, or the Ten Plagues of Egypt, with Ancient and Modern Illustrations. Woodcuts. Post 8vo. 7*s.* 6*d.*

MILMAN (DEAN). History of the Jews, from the earliest Period down to Modern Times. 3 Vols. Post 8vo. 18*s.*

———— Early Christianity, from the Birth of Christ to the Abolition of Paganism in the Roman Empire. 3 Vols. Post 8vo. 18*s.*

———— Latin Christianity, including that of the Popes to the Pontificate of Nicholas V. 9 Vols. Post 8vo. 54*s.*

———— Annals of St. Paul's Cathedral, from the Romans to the funeral of Wellington. Portrait and Illustrations. 8vo. 18*s.*

———— Character and Conduct of the Apostles considered as an Evidence of Christianity. 8vo. 10*s.* 6*d.*

———— Quinti Horatii Flacci Opera. With 100 Woodcuts. Small 8vo. 7*s.* 6*d.*

———— Life of Quintus Horatius Flaccus. With Illustrations. 8vo. 9*s.*

———— Poetical Works. The Fall of Jerusalem—Martyr of Antioch—Balshazzar—Tamor—Anne Boleyn—Fazio, &c. With Portrait and Illustrations. 3 Vols. Fcap. 8vo. 18*s.*

———— Fall of Jerusalem. Fcap. 8vo. 1*s.*

———— (CAPT. E. A.) Wayside Cross. Post 8vo. 2*s.*

MIVART'S (ST. GEORGE) Lessons from Nature; as manifested in Mind and Matter. 8vo. 16*s.*

MODERN DOMESTIC COOKERY. Founded on Principles of Economy and Practical Knowledge. *New Edition.* Woodcuts. Fcap. 8vo. 5*s.*

MONGREDIEN (AUGUSTUS). Trees and Shrubs for English Plantation. A Selection and Description of the most Ornamental which will flourish in the open air in our climate. With Classified Lists. With 30 Illustrations. 8vo. 16*s.*

MOORE'S (THOMAS) Life and Letters of Lord Byron. *Cabinet Edition.* With Plates. 6 Vols. Fcap. 8vo. 18*s.*; *Popular Edition*, with Portraits. Royal 8vo. 7*s.* 6*d.*

MORESBY (CAPT.), R.N. Discoveries in New Guinea, Polynesia, Torres Straits, &c., during the cruise of H.M.S. Basilisk. Map and Illustrations. 8vo. 15*s.*

MOTLEY (J. L.). History of the United Netherlands: from the Death of William the Silent to the Twelve Years' Truce, 1609. *Library Edition.* Portraits. 4 Vols. 8vo. 60*s.* *Cabinet Edition.* 4 Vols. Post 8vo. 6*s.* each.

———— Life and Death of John of Barneveld, Advocate of Holland. With a View of the Primary Causes and Movements of the Thirty Years' War. *Library Edition.* Illustrations. 2 Vols. 8vo. 28*s.* *Cabinet Edition.* 2 vols. Post 8vo. 12*s.*

MOSSMAN (SAMUEL). New Japan; the Land of the Rising Sun; its Annals and Progress during the past Twenty Years, recording the remarkable Progress of the Japanese in Western Civilisation. With Map. 8vo. 15*s*.

MOUHOT (HENRI). Siam, Cambojia, and Lao; a Narrative of Travels and Discoveries. Illustrations. 2 Vols. 8vo.

MOZLEY'S (CANON) Treatise on Predestination. 8vo. 14*s*.

——— Primitive Doctrine of Baptismal Regeneration. 8vo. 7*s*. 6*d*.

MUIRHEAD'S (JAS.) Vaux-de-Vire of Maistre Jean Le Houx, Advocate of Vire. Translated and Edited. With Portrait and Illustrations. 8vo. 21*s*.

MUNRO'S (GENERAL) Life and Letters. By REV. G. R. GLEIG. Post 8vo. 3*s*. 6*d*.

MURCHISON'S (SIR RODERICK) Siluria; or, a History of the Oldest rocks containing Organic Remains. Map and Plates. 8vo. 18*s*.

——— Memoirs. With Notices of his Contemporaries, and Rise and Progress of Palæozoic Geology. By ARCHIBALD GEIKIE. Portraits. 2 Vols. 8vo. 30*s*.

MURRAY'S RAILWAY READING. Containing:—

WELLINGTON. By LORD ELLESMERE. 6*d*.
NIMROD ON THE CHASE, 1*s*.
MUSIC AND DRESS. 1*s*.
MILMAN'S FALL OF JERUSALEM. 1*s*.
MAHON'S "FORTY-FIVE." 3*s*.
LIFE OF THEODORE HOOK. 1*s*.
DEEDS OF NAVAL DARING. 3*s*. 6*d*.
THE HONEY BEE. 1*s*.
ÆSOP'S FABLES. 2*s*. 6*d*.
NIMROD ON THE TURF. 1*s*. 6*d*.
ART OF DINING. 1*s*. 6*d*.
MAHON'S JOAN OF ARC. 1*s*.
HEAD'S EMIGRANT. 2*s*. 6*d*.
NIMROD ON THE ROAD. 1*s*.
CROKER ON THE GUILLOTINE. 1*s*.
HOLLWAY'S NORWAY. 2*s*.
MAUREL'S WELLINGTON. 1*s*. 6*d*.
CAMPBELL'S LIFE OF BACON. 2*s*. 6*d*.
THE FLOWER GARDEN. 1*s*.
TAYLOR'S NOTES FROM LIFE. 2*s*.
REJECTED ADDRESSES. 1*s*.
PENN'S HINTS ON ANGLING. 1*s*.

MUSTERS' (CAPT.) Patagonians; a Year's Wanderings over Untrodden Ground from the Straits of Magellan to the Rio Negro. Illustrations. Post 8vo. 7*s*. 6*d*.

NAPIER (SIR WM.). English Battles and Sieges of the Peninsular War. Portrait. Post 8vo. 9*s*.

NAPOLEON AT FONTAINEBLEAU AND ELBA. A Journal of Occurrences and Notes of Conversations. By SIR NEIL CAMPBELL, C.B. With a Memoir. By REV. A. N. C. MACLACHLAN, M.A. Portrait. 8vo. 15*s*.

NARES (SIR GEORGE), R.N. Official Report to the Admiralty of the recent Arctic Expedition. Map. 8vo. 2*s*. 6*d*.

NASMYTH AND CARPENTER. The Moon. Considered as a Planet, a World, and a Satellite. With Illustrations from Drawings made with the aid of Powerful Telescopes, Woodcuts, &c. 4to. 30*s*.

NAUTICAL ALMANAC (THE). (*By Authority.*) 2*s*. 6*d*.

NAVY LIST. (Monthly and Quarterly.) Post 8vo.

NEW TESTAMENT. With Short Explanatory Commentary. By ARCHDEACON CHURTON, M.A., and ARCHDEACON BASIL JONES, M.A. With 110 authentic Views, &c. 2 Vols. Crown 8vo 21*s*. *bound*.

NEWTH (SAMUEL). First Book of Natural Philosophy; an Introduction to the Study of Statics, Dynamics, Hydrostatics, Optics, and Acoustics, with numerous Examples. Small 8vo. 3*s*. 6*d*.

——— Elements of Mechanics, including Hydrostatics, with numerous Examples. Small 8vo. 8*s*. 6*d*.

——— Mathematical Examinations. A Graduated Series of Elementary Examples in Arithmetic, Algebra, Logarithms, Trigonometry, and Mechanics. Small 8vo. 8*s*. 6*d*.

NICHOLS' (J. G.) Pilgrimages to Walsingham and Canterbury. By ERASMUS. Translated, with Notes. With Illustrations. Post 8vo. 6*s*.

——— (SIR GEORGE) History of the English Poor Laws. 2 Vols. 8vo.

NICOLAS' (SIR HARRIS) Historic Peerage of England. Exhibiting the Origin, Descent, and Present State of every Title of Peerage which has existed in this Country since the Conquest. By WILLIAM COURTHOPE. 8vo. 30*s.*

NIMROD, On the Chace—Turf—and Road. With Portrait and Plates. Crown 8vo. 5*s.* Or with Coloured Plates, 7*s.* 6*d.*

NORDHOFF (CHAS.). Communistic Societies of the United States; including Detailed Accounts of the Shakers, The Amana, Oneida, Bethell, Aurora, Icarian and other existing Societies; with Particulars of their Religious Creeds, Industries, and Present Condition. With 40 Illustrations. 8vo. 15*s.*

ORMATHWAITE (LORD). Astronomy and Geology. Crown 8vo. 6*s.*

OWEN (LIEUT.-COL.). Principles and Practice of Modern Artillery, including Artillery Material, Gunnery, and Organisation and Use of Artillery in Warfare. With Illustrations. 8vo. 15*s.*

OXENHAM (REV. W.). English Notes for Latin Elegiacs; designed for early Proficients in the Art of Latin Versification, with Prefatory Rules of Composition in Elegiac Metre. 12mo. 3*s.* 6*d.*

PALGRAVE (R. H. I.). Local Taxation of Great Britain and Ireland. 8vo. 5*s.*

——— NOTES ON BANKING IN GREAT BRITAIN AND IRELAND, SWEDEN, DENMARK, AND HAMBURG, with some Remarks on the amount of Bills in circulation, both Inland and Foreign. 8vo. 6*s.*

PALLISER (MRS.). Brittany and its Byeways, its Inhabitants, and Antiquities. With Illustrations. Post 8vo. 12*s.*

——— Mottoes for Monuments, or Epitaphs selected for General Use and Study. With Illustrations. Crown 8vo. 7*s.* 6*d.*

PARIS' (DR.) Philosophy in Sport made Science in Earnest; or, the First Principles of Natural Philosophy inculcated by aid of the Toys and Sports of Youth. Woodcuts. Post 8vo. 7*s.* 6*d.*

PARKMAN (FRANCIS). Discovery of the Great West; or, The Valleys of the Mississippi and the Lakes of North America. An Historical Narrative. Map. 8vo. 10*s.* 6*d.*

PARKYNS' (MANSFIELD) Three Years' Residence in Abyssinia: with Travels in that Country. With Illustrations. Post 8vo. 7*s.* 6*d.*

PEEK PRIZE ESSAYS. The Maintenance of the Church of England as an Established Church. By REV. CHARLES HOLE—REV. R. WATSON DIXON—and REV. JULIUS LLOYD. 8vo. 10*s.* 6*d.*

PEEL'S (SIR ROBERT) Memoirs. 2 Vols. Post 8vo. 15*s.*

PENN (RICHARD). Maxims and Hints for an Angler and Chess-player. Woodcuts. Fcap. 8vo. 1*s.*

PERCY (JOHN, M.D.). Metallurgy. Vol. I., Part 1. FUEL, Wood, Peat, Coal, Charcoal, Coke, Refractory Materials, Fire-Clays, &c. With Illustrations. 8vo. 30*s.*

——— Vol. I., Part 2. Copper, Zinc, Brass. With Illustrations. 8vo. [*In the Press.*

——— Vol. II. Iron and Steel. With Illustrations. 8vo. [*In Preparation.*

——— Vol. III. Lead, including part of SILVER. With Illustrations. 8vo. 30*s.*

——— Vols. IV. and V. Gold, Silver, and Mercury, Platinum, Tin, Nickel, Cobalt, Antimony, Bismuth, Arsenic, and other Metals. With Illustrations. 8vo. [*In Preparation.*

PHILLIPS' (JOHN) Memoirs of William Smith. 8vo. 7*s.* 6*d.*

——— Geology of Yorkshire, The Coast, and Limestone District. Plates. 2 Vols. 4to.

——— Rivers, Mountains, and Sea Coast of Yorkshire. With Essays on the Climate, Scenery, and Ancient Inhabitants. Plates. 8vo. 15*s.*

PHILLIPS' (SAMUEL) Literary Essays from "The Times." With Portrait. 2 Vols. Fcap. 8vo. 7*s.*

POPE'S (ALEXANDER) Works. With Introductions and Notes, by REV. WHITWELL ELWIN. Vols. I., II., VI., VII., VIII. With Portraits. 8vo. 10*s.* 6*d.* each.

PORTER (REV. J. L.). Damascus, Palmyra, and Lebanon. With Travels among the Giant Cities of Bashan and the Hauran. Map and Woodcuts. Post 8vo. 7*s.* 6*d.*

PRAYER-BOOK (ILLUSTRATED), with Borders, Initials, Vignettes, &c. Edited, with Notes, by REV. THOS. JAMES. Medium 8vo. 18*s. cloth ;* 31*s.* 6*d. calf;* 36*s. morocco.*

PRINCESS CHARLOTTE OF WALES. A Brief Memoir. With Selections from her Correspondence and other unpublished Papers. By LADY ROSE WEIGALL. With Portrait. 8vo. 8*s.* 6*d.*

PUSS IN BOOTS. With 12 Illustrations. By OTTO SPECKTER. 16mo. 1*s.* 6*d.* Or coloured, 2*s.* 6*d.*

PRIVY COUNCIL JUDGMENTS in Ecclesiastical Cases relating to Doctrine and Discipline. With Historical Introduction, by G. C. BRODRICK and W. H. FREMANTLE. 8vo. 10*s.* 6*d.*

QUARTERLY REVIEW (THE). 8vo. 6*s.*

RAE (EDWARD). Land of the North Wind; or Travels among the Laplanders and Samoyedes, and along the Shores of the White Sea. With Map and Woodcuts. Post 8vo. 10*s.* 6*d.*

RAMBLES in the Syrian Deserts. Post 8vo. 10*s.* 6*d.*

RANKE'S (LEOPOLD) History of the Popes of Rome during the 16th and 17th Centuries. Translated from the German by SARAH AUSTIN. 3 Vols. 8vo. 30*s.*

RASSAM (HORMUZD). Narrative of the British Mission to Abyssinia. With Notices of the Countries Traversed from Massowah to Magdala. Illustrations. 2 Vols. 8vo. 28*s.*

RAWLINSON'S (CANON) Herodotus. A New English Version. Edited with Notes and Essays. Maps and Woodcut. 4 Vols. 8vo. 48*s.*

——— Five Great Monarchies of Chaldæa, Assyria, Media, Babylonia, and Persia. With Maps and Illustrations. 3 Vols. 8vo. 42*s.*

——— (SIR HENRY) England and Russia in the East; a Series of Papers on the Political and Geographical Condition of Central Asia. Map. 8vo. 12*s.*

REED (E. J.). Shipbuilding in Iron and Steel; a Practical Treatise, giving full details of Construction, Processes of Manufacture, and Building Arrangements. With 5 Plans and 250 Woodcuts. 8vo.

——— Iron-Clad Ships; their Qualities, Performances, and Cost. With Chapters on Turret Ships, Iron-Clad Rams, &c. With Illustrations. 8vo. 12*s.*

——— Letters from Russia in 1875. 8vo. 5*s.*

REJECTED ADDRESSES (THE). By JAMES AND HORACE SMITH. Woodcuts. Post 8vo. 3*s.* 6*d.*; or *Popular Edition*, Fcap. 8vo. 1*s.*

REYNOLDS' (SIR JOSHUA) Life and Times. By C. R. LESLIE, R.A. and TOM TAYLOR. Portraits. 2 Vols. 8vo.

RICARDO'S (DAVID) Political Works. With a Notice of his Life and Writings. By J. R. M'CULLOCH. 8vo. 16*s.*

RIPA'S (FATHER) Thirteen Years' Residence at the Court of Peking. Post 8vo. 2*s.*

ROBERTSON (CANON). History of the Christian Church, from the Apostolic Age to the Reformation, 1517. *Library Edition.* 4 Vols. 8vo. *Cabinet Edition.* 8 Vols. Post 8vo. 6*s.* each.

ROME (HISTORY OF). *See* LIDDELL and SMITH.

ROWLAND (DAVID). Manual of the English Constitution. Its Rise, Growth, and Present State. Post 8vo. 10s. 6d.

——— Laws of Nature the Foundation of Morals. Post 8vo. 6s.

ROBSON (E. R.). SCHOOL ARCHITECTURE. Being Practical Remarks on the Planning, Designing, Building, and Furnishing of School-houses. With 300 Illustrations. Medium 8vo. 18s.

RUNDELL'S (MRS.) Modern Domestic Cookery. Fcap. 8vo. 5s.

RUXTON (GEORGE F.). Travels in Mexico; with Adventures among the Wild Tribes and Animals of the Prairies and Rocky Mountains. Post 8vo. 3s. 6d.

ROBINSON (REV. DR.). Biblical Researches in Palestine and the Adjacent Regions, 1838—52. Maps. 3 Vols. 8vo. 42s.

——— Physical Geography of the Holy Land. Post 8vo. 10s. 6d.

——— (WM.) Alpine Flowers for English Gardens. With 70 Illustrations. Crown 8vo. 12s.

——— Wild Gardens; or, our Groves and Shrubberies made beautiful by the Naturalization of Hardy Exotic Plants. With Frontispiece. Small 8vo. 6s.

——— Sub-Tropical Gardens; or, Beauty of Form in the Flower Garden. With Illustrations. Small 8vo. 7s. 6d.

SALE'S (SIR ROBERT) Brigade in Affghanistan. With an Account of the Defence of Jellalabad. By REV. G. R. GLEIG. Post 8vo. 2s.

SCHLIEMANN (DR. HENRY). Troy and Its Remains. A Narrative of Researches and Discoveries made on the Site of Ilium, and in the Trojan Plain. With Maps, Views, and 500 Illustrations. Medium 8vo. 42s.

——— Discoveries on the Site of Ancient Mycenæ. With numerous Illustrations, Plans, &c. Medium 8vo. [*In Preparation.*

SCOTT (SIR G. G.). Secular and Domestic Architecture, Present and Future. 8vo. 9s.

——— (DEAN) University Sermons. Post 8vo. 8s. 6d.

SHADOWS OF A SICK ROOM. With a Preface by Canon LIDDON. 16mo. 2s 6d.

SHAH OF PERSIA'S Diary during his Tour through Europe in 1873. Translated from the Original. By J. W. REDHOUSE. With Portrait and Coloured Title. Crown 8vo. 12s.

SCROPE (G. P.). Geology and Extinct Volcanoes of Central France. Illustrations. Medium 8vo. 30s.

SMILES' (SAMUEL) British Engineers; from the Earliest Period to the death of the Stephensons. With Illustrations. 5 Vols. Crown 8vo. 7s. 6d. each.

——— George and Robert Stephenson. Illustrations. Medium 8vo. 21s.

——— Boulton and Watt. Illustrations. Medium 8vo. 21s.

——— Life of a Scotch Naturalist (Thomas Edward). With Portrait and Illustrations. Crown 8vo. 10s 6d.

——— Huguenots in England and Ireland. Crown 8vo. 7s. 6d.

——— Self-Help. With Illustrations of Conduct and Perseverance. Post 8vo. 6s. Or in French, 5s.

——— Character. A Sequel to "SELF-HELP." Post 8vo. 6s.

——— THRIFT. A Book of Domestic Counsel. Post 8vo. 6s.

——— Industrial Biography; or, Iron Workers and Tool Makers. Post 8vo. 6s.

——— Boy's Voyage round the World. With Illustrations. Post 8vo. 6s.

SMITH'S (Dr. Wm.) Dictionary of the Bible; its Antiquities, Biography, Geography, and Natural History. Illustrations. 3 Vols. 8vo. 105*s.*

——— Concise Bible Dictionary. With 300 Illustrations. Medium 8vo. 21*s.*

——— Smaller Bible Dictionary. With Illustrations. Post 8vo. 7*s.* 6*d.*

——— Christian Antiquities. Comprising the History, Institutions, and Antiquities of the Christian Church. With Illustrations. Vol. I. 8vo. 31*s.* 6*d.*

——— ——— Biography, Literature, Sects, and Doctrines; from the Times of the Apostles to the Age of Charlemagne. Vol. I. 8vo. 31*s.* 6*d.*

——— Atlas of Ancient Geography—Biblical and Classical. Folio. 6*l.* 6*s.*

——— Greek and Roman Antiquities. With 500 Illustrations. Medium 8vo. 28*s.*

——— ——— ——— Biography and Mythology. With 600 Illustrations. 3 Vols. Medium 8vo. 4*l.* 4*s.*

——— ——— ——— Geography. 2 Vols. With 500 Illustrations. Medium 8vo. 56*s.*

——— Classical Dictionary of Mythology, Biography, and Geography. 1 Vol. With 750 Woodcuts. 8vo. 18*s.*

——— Smaller Classical Dictionary. With 200 Woodcuts. Crown 8vo. 7*s.* 6*d.*

——— Smaller Greek and Roman Antiquities. With 200 Woodcuts. Crown 8vo. 7*s.* 6*d.*

——— Complete Latin-English Dictionary. With Tables of the Roman Calendar, Measures, Weights, and Money. 8vo. 21*s.*

——— Smaller Latin-English Dictionary. 12mo. 7*s.* 6*d.*

——— Copious and Critical English-Latin Dictionary. 8vo. 21*s.*

——— Smaller English-Latin Dictionary. 12mo. 7*s.* 6*d.*

——— School Manual of English Grammar, with Copious Exercises. Post 8vo. 3*s.* 6*d.*

——— ——— Modern Geography, Physical and Political. Post 8vo. 5*s.*

——— Primary English Grammar. 16mo. 1*s.*

——— ——— History of Britain. 12mo. 2*s.* 6*d.*

——— French Principia. Part I. A First Course, containing a Grammar, Delectus, Exercises, and Vocabularies. 12mo. 3*s.* 6*d.*

——— ——— Part II. A Reading Book, containing Fables, Stories, and Anecdotes, Natural History, and Scenes from the History of France. With Grammatical Questions, Notes and copious Etymological Dictionary. 12mo. 4*s.* 6*d.*

——— ——— Part III. Prose Composition, containing a Systematic Course of Exercises on the Syntax, with the Principal Rules of Syntax. 12mo. [*In the Press.*

——— Student's French Grammar. By C. Heron-Wall. With Introduction by M. Littré. Post 8vo. 7*s.* 6*d.*

——— Smaller Grammar of the French Language. Abridged from the above. 12mo. 3*s.* 6*d.*

——— German Principia, Part I. A First German Course, containing a Grammar, Delectus, Exercise Book, and Vocabularies. 12mo. 3*s.* 6*d.*

SMITH'S (Dr. Wm.) German Principia, Part II. A Reading Book; containing Fables, Stories, and Anecdotes, Natural History, and Scenes from the History of Germany. With Grammatical Questions, Notes, and Dictionary. 12mo. 3*s.* 6*d.*

—— Part III. An Introduction to German Prose Composition; containing a Systematic Course of Exercises on the Syntax, with the Principal Rules of Syntax. 12mo. [*In the Press.*

—— Practical German Grammar. Post 8vo. 3*s.* 6*d.*

—— Principia Latina—Part I. First Latin Course, containing a Grammar, Delectus, and Exercise Book, with Vocabularies. 12mo. 3*s.* 6*d.*

*** In this Edition the Cases of the Nouns, Adjectives, and Pronouns are arranged both as in the ORDINARY GRAMMARS and as in the PUBLIC SCHOOL PRIMER, together with the corresponding Exercises.

—— Part II. A Reading-book of Mythology, Geography, Roman Antiquities, and History. With Notes and Dictionary. 12mo. 3*s.* 6*d.*

—— Part III. A Poetry Book. Hexameters and Pentameters; Eclog. Ovidianæ; Latin Prosody. 12mo. 3*s.* 6*d.*

—— Part IV. Prose Composition. Rules of Syntax with Examples, Explanations of Synonyms, and Exercises on the Syntax. 12mo. 3*s.* 6*d.*

—— Principia Latina—Part V. Short Tales and Anecdotes for Translation into Latin. 12mo. 3*s.*

—— Latin-English Vocabulary and First Latin-English Dictionary for Phædrus, Cornelius Nepos, and Cæsar. 12mo. 3*s.* 6*d.*

—— Student's Latin Grammar. Post 8vo. 6*s.*

—— Smaller Latin Grammar. 12mo. 3*s.* 6*d.*

—— Tacitus, Germania, Agricola, &c. With English Notes. 12mo. 3*s.* 6*d.*

—— Initia Græca, Part I. A First Greek Course, containing a Grammar, Delectus, and Exercise-book. With Vocabularies. 12mo. 3*s.* 6*d.*

—— Part II. A Reading Book. Containing Short Tales, Anecdotes, Fables, Mythology, and Grecian History. 12mo. 3*s.* 6*d.*

—— Part III. Prose Composition. Containing the Rules of Syntax, with copious Examples and Exercises. 12mo. 3*s.* 6*d.*

—— Student's Greek Grammar. By CURTIUS. Post 8vo. 6*s.*

—— Smaller Greek Grammar. 12mo. 3*s.* 6*d.*

—— Greek Accidence. 12mo. 2*s.* 6*d.*

—— Plato, Apology of Socrates, &c., with Notes. 12mo. 3*s.* 6*d.*

—— Smaller Scripture History. Woodcuts. 16mo. 3*s.* 6*d.*

—— Ancient History. Woodcuts. 16mo. 3*s.* 6*d.*

—— Geography. Woodcuts. 16mo. 3*s.* 6*d.*

—— Rome. Woodcuts. 16mo. 3*s.* 6*d.*

—— Greece. Woodcuts. 16mo. 3*s.* 6*d.*

—— Classical Mythology. Woodcuts 16mo. 3*s.* 6*d.*

—— History of England. Woodcuts. 16mo. 3*s.* 6*d.*

—— English Literature. 16mo. 3*s.* 6*d.*

—— Specimens of English Literature. 16mo. 3*s.* 6*d.*

STANLEY (Dean). Sinai and Palestine, in connexion with their History. Map. 8vo. 14*s*.

——— Bible in the Holy Land; Extracted from the above Work. Woodcuts. Fcap. 8vo. 2*s*. 6*d*.

——— Eastern Church. Plans. 8vo. 12*s*.

——— Jewish Church. 1*st & 2nd Series*. From the Earliest Times to the Captivity. 2 Vols. 8vo. 24*s*.

——— *Third Series*. From the Captivity to the Destruction of Jerusalem. 8vo. 14*s*.

——— Epistles of St. Paul to the Corinthians. 8vo. 18s.

——— Life of Dr. Arnold, of Rugby. With selections from his Correspondence. With portrait. 2 vols. Crown 8vo. 12*s*.

——— Church of Scotland. 8vo. 7*s*. 6*d*.

——— Memorials of Canterbury Cathedral. Woodcuts. Post 8vo. 7*s*. 6*d*.

——— Westminster Abbey. With Illustrations. 8vo. 15*s*.

——— Sermons during a Tour in the East. 8vo. 9*s*.

——— Addresses and Charges of the late Bishop Stanley. With Memoir. 8vo. 10*s*. 6*d*.

SHAW (T. B.). Student's Manual of English Literature. Post 8vo. 7*s*. 6*d*.

——— Specimens of English Literature. Selected from the Chief Writers. Post 8vo. 7*s*. 6*d*.

——— (Robert). Visit to High Tartary, Yarkand, and Kashgar (formerly Chinese Tartary), and Return Journey over the Karakorum Pass. With Map and Illustrations. 8vo. 16*s*.

SHIRLEY (Evelyn P.). Deer and Deer Parks; or some Account of English Parks, with Notes on the Management of Deer. Illustrations. 4to. 21*s*.

SIERRA LEONE; Described in Letters to Friends at Home. By A Lady. Post 8vo. 3*s*. 6*d*.

SMITH'S (Philip) History of the Ancient World, from the Creation to the Fall of the Roman Empire, A.D. 476. *Fourth Edition*. 3 Vols. 8vo. 31*s*. 6*d*.

SIMMONS' (Capt.) Constitution and Practice of Courts-Martial. *Seventh Edition*. 8vo. 15*s*.

SPALDING'S (Captain) Tale of Frithiof. Translated from the Swedish of Esias Tegner. Post 8vo. 7*s*. 6*d*.

STEPHEN (Rev. W. R.). Life and Times of St. Chrysostom. With Portrait. 8vo. 15*s*.

ST. JAMES LECTURES. Companions for the Devout Life. 2 Vols. 8vo. 7*s*. 6*d*. each.

First Series, 1875.

Imitation of Christ. Canon Farrar.
Pensées of Blaise Pascal. Dean Church.
S. François de Sales. Dean Goulburn.
Baxter's Saints' Rest. Archbishop Trench.
S. Augustine's Confessions. Bishop Alexander.
Jeremy Taylor's Holy Living and Dying. Rev. Dr Humphry.

Second Series, 1876.

Theologia Germanica. Canon Ashwell.
Fénelon's Œuvres Spirituelles. Rev. T. T. Carter.
Andrewes' Devotions. Bishop of Ely.
Christian Year. Canon Barry.
Paradise Lost. Rev. E. H. Bickersteth.
Pilgrim's Progress. Dean Howson.
Prayer Book. Dean Burgon.

ST. JOHN'S (Charles) Wild Sports and Natural History of the Highlands. Post 8vo. 8*s*. 6*d*.

——— (Bayle) Adventures in the Libyan Desert. Post 8vo. 2*s*.

STUDENT'S OLD TESTAMENT HISTORY; from the Creation to the Return of the Jews from Captivity. Maps and Woodcuts. Post 8vo. 7*s*. 6*d*.

——— NEW TESTAMENT HISTORY. With an Introduction connecting the History of the Old and New Testaments. Maps and Woodcuts. Post 8vo. 7*s*. 6*d*.

——— ECCLESIASTICAL HISTORY. A History of the Christian Church from its Foundation to the Eve of the Protestant Reformation. Post 8vo. 7*s* 6*d*.

——— ANCIENT HISTORY OF THE EAST; Egypt, Assyria, Babylonia, Media, Persia, Asia Minor, and Phœnicia. Woodcuts. Post 8vo. 7*s*. 6*d*.

——— GEOGRAPHY. By Rev. W. L. Bevan. Woodcuts. Post 8vo. 7*s*. 6*d*.

——— HISTORY OF GREECE; from the Earliest Times to the Roman Conquest. By Wm. Smith, D.C.L. Woodcuts. Crown 8vo. 7*s*. 6*d*.

*** Questions on the above Work, 12mo. 2*s*.

——— HISTORY OF ROME; from the Earliest Times to the Establishment of the Empire. By Dean Liddell. Woodcuts. Crown 8vo. 7*s*. 6*d*.

——— GIBBON'S Decline and Fall of the Roman Empire. Woodcuts. Post 8vo. 7*s*. 6*d*.

——— HALLAM'S HISTORY OF EUROPE during the Middle Ages. Post 8vo. 7*s*. 6*d*.

——— HALLAM'S HISTORY OF ENGLAND; from the Accession of Henry VII. to the Death of George II. Post 8vo. 7*s*. 6*d*.

——— HUME'S History of England from the Invasion of Julius Cæsar to the Revolution in 1688. Continued down to 1868. Woodcuts. Post 8vo. 7*s*. 6*d*.

*** Questions on the above Work, 12mo. 2*s*.

——— HISTORY OF FRANCE; from the Earliest Times to the Establishment of the Second Empire, 1852. By Rev. H. W. Jervis. Woodcuts. Post 8vo. 7*s*. 6*d*.

——— ENGLISH LANGUAGE. By Geo. P. Marsh. Post 8vo. 7*s*. 6*d*.

——— LITERATURE. By T. B. Shaw, M.A. Post 8vo. 7*s*. 6*d*.

——— SPECIMENS of English Literature from the Chief Writers. By T. B. Shaw, Post 8vo. 7*s*. 6*d*.

——— MODERN GEOGRAPHY; Mathematical, Physical, and Descriptive. By Rev. W. L. Bevan. Woodcuts. Post 8vo. 7*s*. 6*d*.

——— MORAL PHILOSOPHY. By William Fleming, D.D. Post 8vo. 7*s*. 6*d*.

——— BLACKSTONE'S Commentaries on the Laws of England. By R. Malcolm Kerr, LL.D. Post 8vo. 7*s*. 6*d*.

SUMNER'S (Bishop) Life and Episcopate during 40 Years. By Rev. G. H. Sumner. Portrait. 8vo. 14*s*.

STREET (G. E.) Gothic Architecture in Spain. From Personal Observations made during several Journeys. With Illustrations. Royal 8vo. 30*s*.

——— Italy, chiefly in Brick and Marble. With Notes of Tours in the North of Italy. With 60 Illustrations. Royal 8vo. 26*s*.

STANHOPE (EARL) England from the Reign of Queen Anne to the Peace of Versailles, 1701-83. *Library Edition.* 8 vols. 8vo. *Cabinet Edition*, 9 vols. Post 8vo. 5*s.* each.

——— British India, from its Origin to 1783. 8vo. 3*s.* 6*d.*

——— History of "Forty-Five." Post 8vo. 3*s.*

——— Historical and Critical Essays. Post 8vo. 3*s.* 6*d.*

——— French Retreat from Moscow, and other Essays. Post 8vo. 7*s.* 6*d.*

——— Life of Belisarius. Post 8vo. 10*s.* 6*d.*

——— Condé. Post 8vo. 3*s.* 6*d.*

——— William Pitt. Portraits. 4 Vols. 8vo. 24*s.*

——— Miscellanies. 2 Vols. Post 8vo. 13*s.*

——— Story of Joan of Arc. Fcap. 8vo. 1*s.*

——— Addresses on Various Occasions. 16mo. 1*s.*

STYFFE'S (KNUTT) Strength of Iron and Steel. Plates. 8vo. 12*s.*

SOMERVILLE'S (MARY) Personal Recollections from Early Life to Old Age. With her Correspondence. Portrait. Crown 8vo. 12*s.*

——— Physical Geography. Portrait. Post 8vo. 9*s.*

——— Connexion of the Physical Sciences. Portrait. Post 8vo. 9*s.*

——— Molecular and Microscopic Science. Illustrations. 2 Vols. Post 8vo. 21*s.*

SOUTHEY'S (ROBERT) Lives of Bunyan and Cromwell. Post 8vo. 2*s.*

SWAINSON (CANON). Nicene and Apostles' Creeds; Their Literary History; together with some Account of "The Creed of St. Athanasius." 8vo.

SYBEL (VON) History of Europe during the French Revolution, 1789—1795. 4 Vols. 8vo. 48*s.*

SYMONDS' (REV. W.) Records of the Rocks; or Notes on the Geology, Natural History, and Antiquities of North and South Wales, Siluria, Devon, and Cornwall. With Illustrations. Crown 8vo. 12*s.*

THIBAUT (ANTOINE) On Purity in Musical Art. Translated from the German. With a prefatory Memoir by W. H. Gladstone, M.P. Post 8vo. [*In preparation.*

THIELMANN (BARON) Journey through the Caucasus to Tabreez, Kurdistan, down the Tigris and Euphrates to Nineveh and Babylon, and across the Desert to Palmyra. Translated by CHAS. HENEAGE. Illustrations. 2 Vols. Post 8vo. 18*s.*

THOMS' (W. J.) Longevity of Man; its Facts and its Fiction. Including Observations on the more Remarkable Instances. Post 8vo. 10*s.* 6*d.*

THOMSON'S (ARCHBISHOP) Lincoln's Inn Sermons. 8vo. 10*s.* 6*d.*

——— Life in the Light of God's Word. Post 8vo. 5*s.*

TITIAN. His Life and Times. With some account of his Family, chiefly from new and unpublished Records. By J. A. CROWE and G. B. CAVALCASELLE. With Portrait and Illustrations. 2 Vols. 8vo. 42*s.*

TOCQUEVILLE'S State of Society in France before the Revolution, 1789, and on the Causes which led to that Event. Translated by HENRY REEVE. 8vo. 12*s.*

TOMLINSON (CHARLES); The Sonnet; Its Origin, Structure, and Place in Poetry. With translations from Dante, Petrarch, &c. Post 8vo. 9*s.*

TOZER (REV. H. F.) Highlands of Turkey, with Visits to Mounts Ida, Athos, Olympus, and Pelion. 2 Vols. Crown 8vo. 24*s.*

——— Lectures on the Geography of Greece. Map. Post 8vo. 9*s.*

TRISTRAM (CANON) Great Sahara. Illustrations. Crown 8vo. 15*s.*

——— Land of Moab; Travels and Discoveries on the East Side of the Dead Sea and the Jordan. Illustrations. Crown 8vo. 15*s.*

TWISLETON (EDWARD). The Tongue not Essential to Speech, with Illustrations of the Power of Speech in the case of the African Confessors. Post 8vo. 6*s.*

TWISS' (HORACE) Life of Lord Eldon. 2 Vols. Post 8vo. 21*s.*

TYLOR (E. B.) Early History of Mankind, and Development of Civilization. 8vo. 12*s.*

——— Primitive Culture; the Development of Mythology, Philosophy, Religion, Art, and Custom. 2 Vols. 8vo. 24*s.*

VAMBERY (ARMINIUS) Travels from Teheran across the Turkoman Desert on the Eastern Shore of the Caspian. Illustrations. 8vo. 21*s.*

VAN LENNEP (HENRY J.) Travels in Asia Minor. With Illustrations of Biblical Literature, and Archæology. With Woodcuts. 2 Vols. Post 8vo. 24*s.*

——— Modern Customs and Manners of Bible Lands, in illustration of Scripture. With Maps and 300 Illustrations. 2 Vols. 8vo. 21*s.*

WELLINGTON'S Despatches during his Campaigns in India, Denmark, Portugal, Spain, the Low Countries, and France. Edited by COLONEL GURWOOD. 8 Vols. 8vo. 20*s.* each.

——— Supplementary Despatches, relating to India, Ireland, Denmark, Spanish America, Spain, Portugal, France, Congress of Vienna, Waterloo and Paris. Edited by his SON. 14 Vols. 8vo. 20*s.* each. *** *An Index.* 8vo. 20*s.*

——— Civil and Political Correspondence. Edited by his SON. Vols. I. to V. 8vo. 20*s.* each.

——— Vol. VI., relating to the Eastern Question of 1829. Russian Intrigues, Turkish Affairs, Treaty of Adrianople, &c. 8vo.

——— Speeches in Parliament. 2 Vols. 8vo. 42*s.*

WHEELER'S (G.) Choice of a Dwelling; a Practical Handbook of Useful Information on Building a House. Plans. Post 8vo. 7*s.* 6*d.*

WHITE (W. H.) Manual of Naval Architecture, for the use of Officers. Illustrations. 8vo.

WILBERFORCE'S (BISHOP) Life of William Wilberforce. Portrait. Crown 8vo. 6*s.*

WILKINSON (SIR J. G.). Manners and Customs of the Ancient Egyptians, their Private Life, Government, Laws, Arts, Manufactures, Religion, &c. A new edition, with additions by the late Author. Edited by SAMUEL BIRCH, LL.D. Illustrations. 3 Vols. 8vo.

——— Popular Account of the Ancient Egyptians. With 500 Woodcuts. 2 Vols. Post 8vo. 12*s.*

WOOD'S (CAPTAIN) Source of the Oxus. With the Geography of the Valley of the Oxus. By COL. YULE. Map. 8vo. 12*s.*

WORDS OF HUMAN WISDOM. Collected and Arranged by E. S. With a Preface by CANON LIDDON. Fcap. 8vo. 3*s.* 6*d.*

WORDSWORTH'S (BISHOP) Athens and Attica. Plates. 8vo. 5*s.*

YULE'S (COLONEL) Book of Marco Polo. Illustrated by the Light of Oriental Writers and Modern Travels. With Maps and 80 Plates. 2 Vols. Medium 8vo. 63*s.*